MONTHLY NOTICES

OF THE   *40862*

ROYAL ASTRONOMICAL SOCIETY,

CONTAINING

PAPERS, ABSTRACTS OF PAPERS, AND

REPORTS OF THE PROCEEDINGS

OF THE SOCIETY

FROM NOVEMBER 1889 TO NOVEMBER 1890.

VOL. L.

LONDON:

ROYAL ASTRONOMICAL SOCIETY,

BURLINGTON HOUSE, W.

1890.

MONTHLY NOTICES

W. H. M. CHRISTIE, M.A., F.R.S., President, in the Chair.

Richard Evan Day, M.A., 135 Fellows Road, Hampstead, N.W.;
Philip F. Duke, Hendon, Middlesex;
The Rev. Thomas Jones, B.A., LL.D., Curdworth Rectory,
    Birmingham,
were balloted for and duly elected Fellows of the Society.

S. C. Chandler, Harvard College, Cambridge, Mass., U.S.A.;
N. C. Dunér, Director of the Observatory, Upsala, Sweden;
Paul Henry, Astronome à l'Observatoire, Paris;
Prosper Henry, Astronome à l'Observatoire, Paris,
were balloted for and duly elected Associates of the Society.

The following candidates were proposed as Fellows of the
Society, the name of the proposer from personal knowledge
being appended:—

Albert Fowell Austin, Schoolmaster, Luton, Bedfordshire
    (proposed by Alfred F. Smith);
Algernon Sidney Bicknell, Staplefield Place, Crawley,
    Sussex (proposed by A. A. Common);
The Rev. George Burgess, The Woodlands, Urmston, Man-
    chester (proposed by the Rev. J. Burgess);
Démétrius Eginitis, D. ès Sc., Astronome à l'Observatoire de
    Paris (proposed by A. Cowper Ranyard);
George Richard Farncombe, M.A., Green Hill, Handsworth,
    near Birmingham (proposed by Sir R. S. Ball);
Vernon Edwin Knocker, Solicitor, Castle Hill House, Dover
    (proposed by Edmund J. Spitta);

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Benjamin Noble, Gloucester House, Newcastle-on-Tyne (proposed by A. Cowper Ranyard);

Henry William Lloyd Tanner, M.A., The Abbotts, Clive Road, Penarth, Cardiff (proposed by Sir James Cockle);

R. Lethbridge Tapscott, Owen's College, Manchester (proposed by the Rev. C. R. Gordon);

William Grasett Thackeray, Royal Observatory, Greenwich (proposed by W. H. M. Christie).

Report of the Eclipse Committee of the Royal Astronomical Society, 1889 *October* 3. Drawn up by H. H. Turner, Secretary to the Committee.

The preparations which have been made since the last meeting of the Committee for observing the Total Solar Eclipse of 1889, December 21–22, are summarised in the following report:—

1. Application was made by the Secretary of the Royal Astronomical Society to the Government Grant Committee of the Royal Society for a sum of 400*l.* for the observation of this eclipse. This application was granted. A sum of 120*l.* has since been paid to Mr. A. A. Common for the mounting of two silver-on-glass mirrors of 20-inch aperture and 45-inch focus, to be used on these expeditions. The mountings are thus the property of the Royal Society by the terms of their grant; and to complete the instruments Mr. Common will present the mirrors to that Society, so that by an expenditure of 120*l.* alone two first-class instruments, of whose excellence more will be said hereafter, will be acquired for eclipse and other work.

Sums of 100*l.* and 120*l.* have also been paid to the observers, the Rev. S. J. Perry and Mr. A. Taylor respectively, for their expenses on the expedition. Mr. Taylor will necessarily make a longer stay at his station, and his journey will be more expensive. The remaining 60*l.* is still in the bank, and will be available for contingencies.

2. On application by the Secretary of this Committee, Messrs. Elder, Dempster & Co., the proprietors of the line of steamers by which Mr. Taylor reaches Loanda, have generously consented to convey him at half the usual fare.

A similar application has been made to the Royal Mail Steamship Company, by whose line the Rev. S. J. Perry reaches Barbados; and the directors have similarly consented to convey him and his assistant to the West Indies for 35*l.* each return fare.

3. Application was made by the Secretary of the Society to the Admiralty for assistance at each of the stations, and the Admiralty have given directions that a vessel should be at the

disposal of each of the observers during the eclipse; and moreover that the one should convey the Rev. S. J. Perry from Barbados to a suitable station on the Salut Isles (on which he has finally decided as the best position), and on the return voyage; and similarly the other should convey Mr. Taylor from Loanda to the station which he may select on the coast, and return with him to Loanda after the eclipse.

4. On application by the Secretary of the Society the Foreign Office has obtained facilities from the French and Portuguese Governments respectively for the expeditious landing of the observers at their respective stations.

5. As regards instrumental equipment:—

A. Captain Abney has lent to the expeditions the two lenses of 4-inch aperture and 5-foot focus, which have previously been used in Egypt (1882), Caroline Island (1883), and Grenada (1886), and one of which was taken to Russia (1887) but without result. Each observer will take one of these lenses.

The mountings for these are—

(1) A portable mounting made by Messrs. Troughton & Simms for Mr. Maunder's use in 1886 (Grenada), and taken to Russia (1887) by Father Perry.

(2) A photo-heliograph mounting used by Dr. Schuster in 1886 (Grenada), and since used by Captain Abney at South Kensington.

(1) is the property of the Royal Society, and (2) belongs to the Royal Observatory, Greenwich.

B. Mr. Common has constructed two silver-on-glass mirrors of 20-inch aperture and 45-inch focus for photographing the corona. The mountings have been made from his design, and purchased with part of the special grant for this eclipse (see paragraph 1). Each observer will take one of these mirrors.

C. A 4-inch theodolite and some tools, the property of the Royal Society, and used in the eclipse expedition of 1886, and a prismatic compass, belonging to the Royal Observatory, Greenwich, have been lent to Mr. Taylor.

D. Application has been made to the Admiralty for the use of two chronometers, and they have granted the use of Arnold 590 (one day), and M'Cabe 133 (one day).

6. *The objects of the expeditions* are threefold:—

I. To detect any possible changes in the corona during the two hours and a half that elapse between totality at the respective stations.

II. To photograph the coronal extension as far as possible.

III. To determine the photometric intensity of the corona.

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Both the pairs of instruments (lenses and mirrors) are available for I.; the mirrors were specially designed for II.; both pairs of instruments would be available for III., but for simplification of the programme the mirrors will not be used in this connection.

As regards object I., the similarity of the instruments has been secured in each case. The atmospheric and astronomical conditions will be somewhat different at the two stations, but by varying the exposure it is hoped to get virtually similar photographs at the two ends of the line.

As regards II., it is generally known that eye observations have traced coronal or quasi-coronal light to immense distances from the Moon's limb, especially when the atmospheric absorption is small (as at great heights), and when care is taken to render the eye sensitive before totality. But it is doubtful whether this extension has been photographed; and eminent photographers consider that there is evidence for the supposed extension being simply diffused light from the sky, and not corona at all. The failure of exposures of say three minutes to give sensibly greater extension than one minute is adduced by Captain Abney as a reason for believing the evidence to be on the whole against the reality of coronal streamers. But it must be remembered that it is only quite recently that photographic objectives of more than a few inches aperture have been employed in eclipse work; and the failure to impress the photographic plate may be simply an indication of the feebleness of the light. With the view of attempting to settle this question, Mr. Common has constructed two mirrors which far out-distance in light-grasping power anything previously available for such work. The aperture of each is 20 inches, and the focal length is 45 inches, which, with full aperture, would give a ratio of 1 : 2¼; but there is an internal diaphragm, aperture 15 inches, placed at ½ the focal length within the focus, which reduces the ratio of effective aperture and focal length to 1 : 3. The advantages gained by this internal diaphragm as regards definition at some distance from the centre of the field are pointed out by General Tennant in *Monthly Notices*, vol. xlvii. p. 244.

It does not seem likely that more favourable instrumental conditions can well be devised, with modern methods, for photographing a faint object such as the outer corona; and even if the result be negative it will therefore be of some value. The chief point to be attended to in the use of the mirrors is thus to get long-exposure pictures. Short exposures will also be of interest, but the question the mirrors were built to settle is the reality of the coronal extension.

As regards III., Captain Abney read a paper to the Royal Astronomical Society in 1889, March (*Monthly Notices*, vol. xlix. p. 285), suggesting that the plates taken out by the observers should be fitted with standard squares such as he had described to the Photographic Society in 1885, and which have since been

used by American observers in 1886 and 1889, January 1.
Captain Abney has kindly consented to make plates for the ex-
peditions, and put on the squares himself. Each plate will then
be available for determining the photometric intensity at any
point of the corona which appears on it.

7. The following instructions to the observers have been
drawn up for approval by the present Committee :—

(*a*) Packing cases to be reclosed as far as possible, and pro-
tected from the weather and damage. Care to be taken not
to damage tin cases.

(*b*) For as many days as possible before the eclipse all the
instruments to be arranged as during the eclipse, and complete
rehearsals of all the operations intended to be made during the
eclipse to be most rigidly carried out.

(*c*) A statement of the days on which these rehearsals have
been made to be given in the report of the operations. A daily
note-book to be kept, and no notes destroyed.

(*d*) Approximate latitude and longitude of station to be deter-
mined and noted, and chronometer rated by any practicable
means. (The naval officers will probably do this with sextant.)

(*e*) Instruments to be focussed, and trial-plates taken, if
possible, at least two days before totality. These trial plates to
be carefully preserved. For the mirrors the focus should be ad-
justed, not for the centre of the plate, but for a region about
$\frac{3}{4}°$ from centre. This must be determined by star photographs.

(*f*) Special attention to be given to the rating of the clocks
at least three days before eclipse. Notes of rates to be carefully
preserved.

(*g*) A quarter of an hour before totality clocks to be wound,
and caps and stops, which had been hitherto used to diminish
the amount of light, to be removed if necessary.

(*h*) The actual method in which time is to be called is left to
the observer, but the timekeepers should be thoroughly and
carefully drilled, and their counting should be in a loud voice.

(*i*) There should also be, if possible, three recorders, whose
business it will be to enter *independently* the exact second called
by the timekeeper when each plate is exposed, and when the
exposure is complete. The notes of each to be handed over to
the observer without comparison *inter se*, and compared by him
as soon as convenient after the eclipse; these records on no
account to be altered, but notes of suggested alterations to be
made.

(*k*) There should also be a person specially detailed to give
out the plates in order. After exposure they should be imme-
diately placed in the receiving dark chamber.

(*l*) At the Salut Isles, Father Perry will take complete
charge of the mirror, and Mr. Rooney (under his direction) of
the lens.

At the African station, Mr. Taylor will take charge of the

lens, and will entrust the mirror to the most capable person available, who shall be under Mr. Taylor's supervision before and after totality, but shall act entirely independently during totality.

(*m*) The following plates are to be exposed :—

With the Lenses.

Mr. Rooney.				Mr. Taylor.
With 1-inch diaphragm 4 secs. ($=\frac{1}{4}$ sec. full)	...			4 secs. ($=\frac{1}{4}$ sec. full)
8 „ ($=\frac{1}{2}$ sec. full)	...			8 „ ($=\frac{1}{2}$ sec. full)
Full aperture 1 sec.	...	...	...	1 sec.
5 secs.	...	...	...	5 secs.
15 „	...	...	...	15 „
40 „	...	...	...	40 „
Sum = 93 secs.				70 „
Totality = 135 „				Sum = 163 secs.
Two at discretion.				Totality = 186 „
(2 secs. or 5 secs. suggested.)				One at discretion.

With the Mirrors.

Father Perry.		Mr. Taylor's assistant.	
1 sec.		1 sec.	
5 secs.		5 secs.	
10 „ } = 76 secs.		10 „ } = 76 secs.	
20 „ } Totality = 135 „		20 „ } Totality = 186 „	
40 „		40 „	
Others at discretion.		Others at discretion.	

(*n*) The plates left to discretion at the end of each series should be developed as soon as possible, as experience with trial plates may suggest. If the development is successful, *and these plates are successfully copied*, the other plates should be developed and copied, but on no account is the development of the earlier plates to be commenced until successful copies are made of the discretionary plates.

Such copies are to be deposited with the most trustworthy person available, to be sent home afterwards on application by the observer.

The pictures should not be overdeveloped, certainly not beyond the point when the densest part of the image can just be seen through the back of the plate.

The two or three developers tried by the observers in England to be thoroughly tested by trial plates before the eclipse. The following is suggested by Captain Abney :—

1. Pyrogallic acid	...	2 grains	
Water	...	...	½ oz.
2. Bromide potass	...	20 grains	
Water	...	...	1 oz.
3. Ammonia (·880)	...	1 part	
Water	...	...	9 parts
4. Sulphite of soda, a saturated solution			

No. 1   ...   ½ oz.
　　2   ...   2 drs.
　　3   ...   30 min.
　　4   ...   2 dr.
Add water up to 2 oz.

(*o*) Careful attention to be paid to the orientation of the plates with both instruments by taking photographs of the Sun (with pin-hole apertures) with the telescope clamped (*clock not driving*), at intervals of one hundred seconds on the same plate—so that the images overlap —on the days before and after the eclipse, at the local time at which the eclipse takes place.

(*p*) The plates available for use with the mirrors, in addition to those exposed during totality, are to be *exposed after totality*, viz. up to three minutes after totality ends at regular intervals, according to the number of plates at disposal. These plates are designed to determine how long the limb of the Moon is visible against the corona. Eye observations may also be made of this phenomenon by competent observers, but not by the photographers themselves.

(*q*) Any other observations or drawings which the observers may superintend are to be so arranged that there shall be no possible interruption of the photographers during the half hour including totality.

8. The instruments have been examined by the observers, and are now all ready for the expedition. The Rev. S. J. Perry has taken several photographs with the 4-inch lens (and previously with a 6-inch lens), to thoroughly test the driving of the clock. He has visited Ealing twice, and examined the mounting and working of the mirrors with Mr. Common.

Mr. Taylor's instruments are already packed for transport. He has taken several photographs with one of the mirrors : notably of the Earth-shine on the crescent Moon—exposure, 3 minutes (the crescent being burnt out); of the nebulæ in the *Pleiades*—exposure, 30 minutes. The definition is good up to half a degree from the centre, and fair beyond that point.

9. This report would be incomplete without an express reference to the generous assistance the expeditions have received from Captain Abney and Mr. Common. The names of these

gentlemen have already been mentioned in several connections; but Mr. Common especially has given a great deal of time and attention to the numerous matters connected with the expeditions; and this kindly assistance will have contributed in no small degree to any success which the expeditions may meet with.

10. The following details as to other stations and observers may be of interest:—

(1) Mr. G. C. Bruce, the meteorological officer at St. Helena, wrote to the Astronomer-Royal, offering, on behalf of His Excellency the Governor, every assistance to any expedition which might be sent out. He was informed that the central line passed about 2° 50′ N. of St. Helena, and that station was not therefore to be occupied.

(2) Professor Holden, of the Lick Observatory, wrote informing the Secretary of the Society that two of his assistants were to proceed to some point in South America for observation of the eclipse, and asking for information as to the movements of our observers. He was informed by the Secretary of this Committee of the general plans of operation, as far as they were then developed.

(3) Mr. J. P. Smith has made inquiries about the voyage to Cayenne, and was referred to the Rev. S. J. Perry.

(4) Information has been received that Miss E. Brown and Miss Jefferies are proceeding to Trinidad to observe the eclipse.

(5) From *Nature,* for 1889, Sept. 12, we learn that the Navy Department in Washington is fitting out an expedition to Muxima, in Angola, about one hundred miles in the interior up the Coanza river. The party will be a large one, under the direction of Professor D. P. Todd, and will remain some time at the station.

(6) Professor Tacchini has applied to the Committee for leave to join the Rev. S. J. Perry in his expedition to the Salut Isles. [October 18. Professor Tacchini has unfortunately been prevented from joining the expedition.]

Areas of Faculæ and Sun-spots, compared with Diurnal Ranges of Magnetic Declination, Horizontal Force, and Vertical Force, as observed at the Royal Observatory, Greenwich, in the Years 1873 to 1888.

(*Communicated by the Astronomer Royal.*)

The three upper curves of Plate I., representing the areas of faculæ, whole spots, and umbræ respectively, exhibit in a graphical form the results given on pages 106, 107, and 108 of

Areas of total Force, and Vertical Force, as observed at the
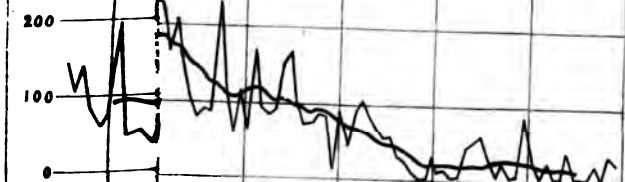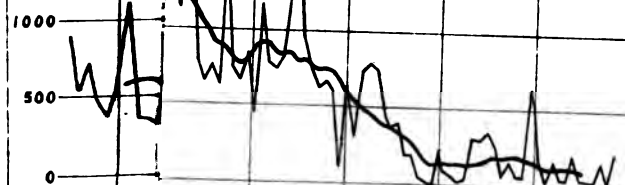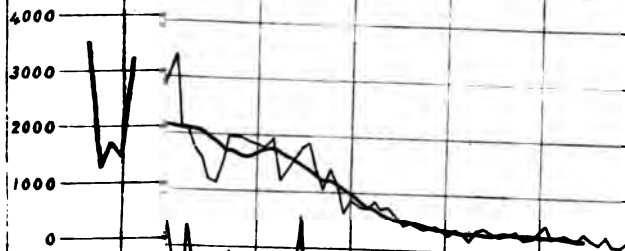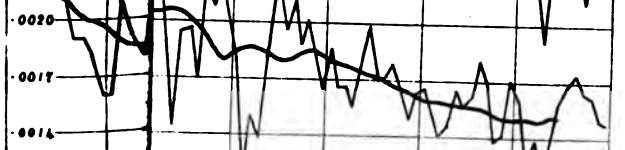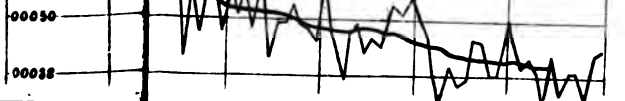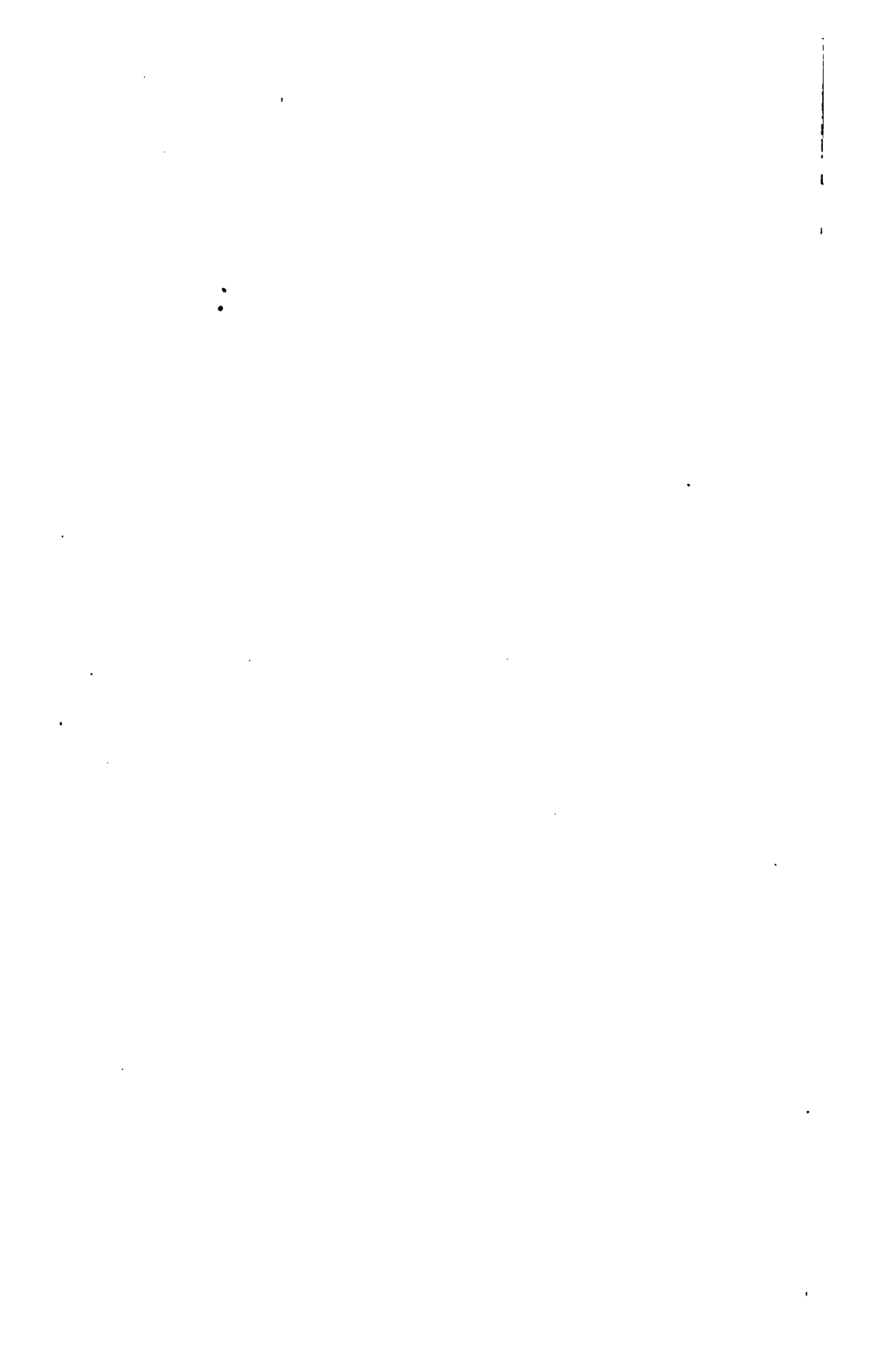
the *Greenwich Spectroscopic and Photographic Results* for 1884, and in similar tables in the volumes for the succeeding years. The mean areas for each of the three orders of solar markings have been formed by taking the means of the areas as measured upon the solar photographs, corrected for foreshortening, and reduced to millionths of the Sun's visible hemisphere, for each day of observation throughout each synodic rotation of the Sun. The commencement of each rotation is defined by the coincidence of the assumed prime meridian with the central meridian, the assumed prime meridian being that meridian which passed through the ascending node at mean noon on 1854, January 1, and the assumed period of the Sun's sidereal rotation being 25·38 days.

The ordinates for the three curves represent, therefore, the mean daily areas for each synodic rotation expressed in millionths of the Sun's visible hemisphere. The scale on which the ordinates have been drawn is five times as large for the nuclei as for the whole spots, and three and one-third times as large for the whole spots as for the faculæ, in order that the variations in each curve might be equally distinct; for the areas of the whole spots are, on the average, about five times as great as those of the nuclei, and of the faculæ about three times as large as of the whole spots. A smooth curve has also been drawn for each of the three orders of phenomena, the ordinates for which correspond at any given rotation to the mean of the areas for thirteen rotations, or of a year very nearly, i.e. the mean of the areas for the rotation in question, for the six rotations immediately preceding it, and for the six immediately following it.

From 1873 to the end of 1881 only the photographs taken at the Royal Observatory, Greenwich, were available for measurement, but from 1881 December 21 the gaps in the Greenwich series have been filled as far as possible by photographs taken at Dehra Dûn, India; and from the beginning of 1885 by photographs taken at the Royal Alfred Observatory, Mauritius, as well. The daily record for the years 1882 to 1888 may, therefore, be considered as practically complete.

In explanation of the construction of the magnetic curves it may be mentioned that the annual volumes of Greenwich observations contain tables, giving for each of the magnetic elements of declination, horizontal force, and vertical force, its mean value at each hour in every month. The difference between the greatest and least of these hourly values in every month is the monthly diurnal range. The values for vertical force are not available until the year 1883, in consequence of difficulty with the temperature correction. The results, both for horizontal force and for vertical force, are corrected for temperature. Now the magnetic diurnal ranges are subject to an annual period, being greatest in summer and least in winter, the period being one which, depending on geographical position, has not necessarily any counterpart in the solar spot variation, and which,

therefore, should be eliminated in order to make comparison with
the Sun-spot curves. The mean monthly value of diurnal range
having been found from the results for the years 1841 to 1877
for declination and horizontal force, and from the results for
1883 to 1888 for vertical force, the differences in each case
between the several mean monthly values and the mean yearly
value give corrections which, applied to the monthly values for
any individual year, clear out the average annual inequality,
leaving only the accidental irregularity remaining. In this way
the irregular-looking curves of diurnal range of magnetic
declination, horizontal force, and vertical force given in the plate
are found.

The smoothed curves are formed as follows:—Assuming
equality in the length of the several calendar months in each
element, the mean of the first twelve values is taken, then the
mean of the second to the thirteenth value, the mean of the
third to the fourteenth value, and so on. Finally, the mean of
each adjacent pair of the means so formed is taken, from which
resulting values the smoothed curve is formed.

The declination range is given in angular measure, and those
of horizontal force and vertical force in parts of the whole
horizontal and vertical forces respectively, the scales being so
arranged that equal changes of absolute magnetic force are
represented by an equal length of ordinate. $1'$ of declination
corresponds to $\cdot 0003$ of horizontal force, and to $\dfrac{\cdot 0003}{\tan \text{dip}} = \cdot 00012$
of vertical force, the values adopted in setting out the various
scales.

Royal Observatory, Greenwich :
        1889 *November* 8.

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*Mean Daily Area of Sun-spots for each Degree of Solar Latitude
for each Year from 1874 to 1888, as measured on Photographs
at the Royal Observatory, Greenwich.*

(*Communicated by the Astronomer Royal.*)

The diagram on Plate II. has been laid down in the fol-
lowing manner. The total areas of whole spots as expressed in
millionths of the Sun's visible hemisphere have been taken out
for each degree of solar latitude for each year, and divided by
the number of days of observation, to give the mean daily area.
In apportioning the different spots to their respective latitudes
the following rule has been observed. If the heliographic lati-
tude of the centre of any single spot, or group of spots when
measured as one, showed $^{\circ}\cdot 5$ or any higher figure in the decimal
place, the entire area of the spot was taken as belonging to the
next higher whole degree of latitude. If it showed $^{\circ}\cdot 4$ or any
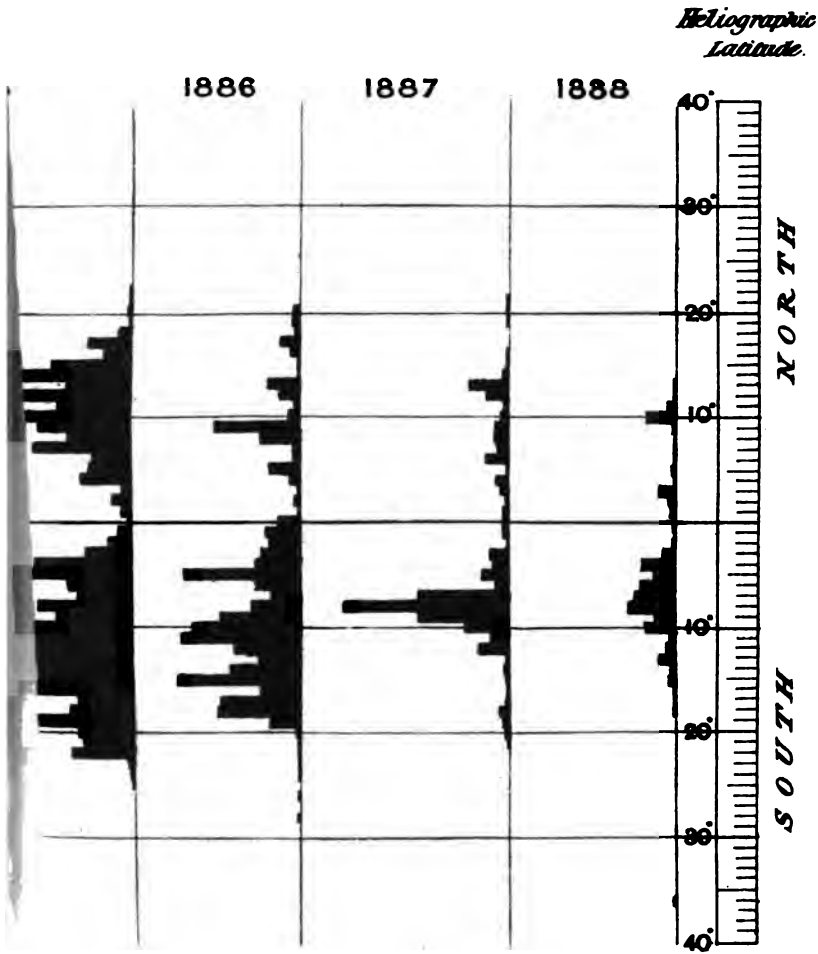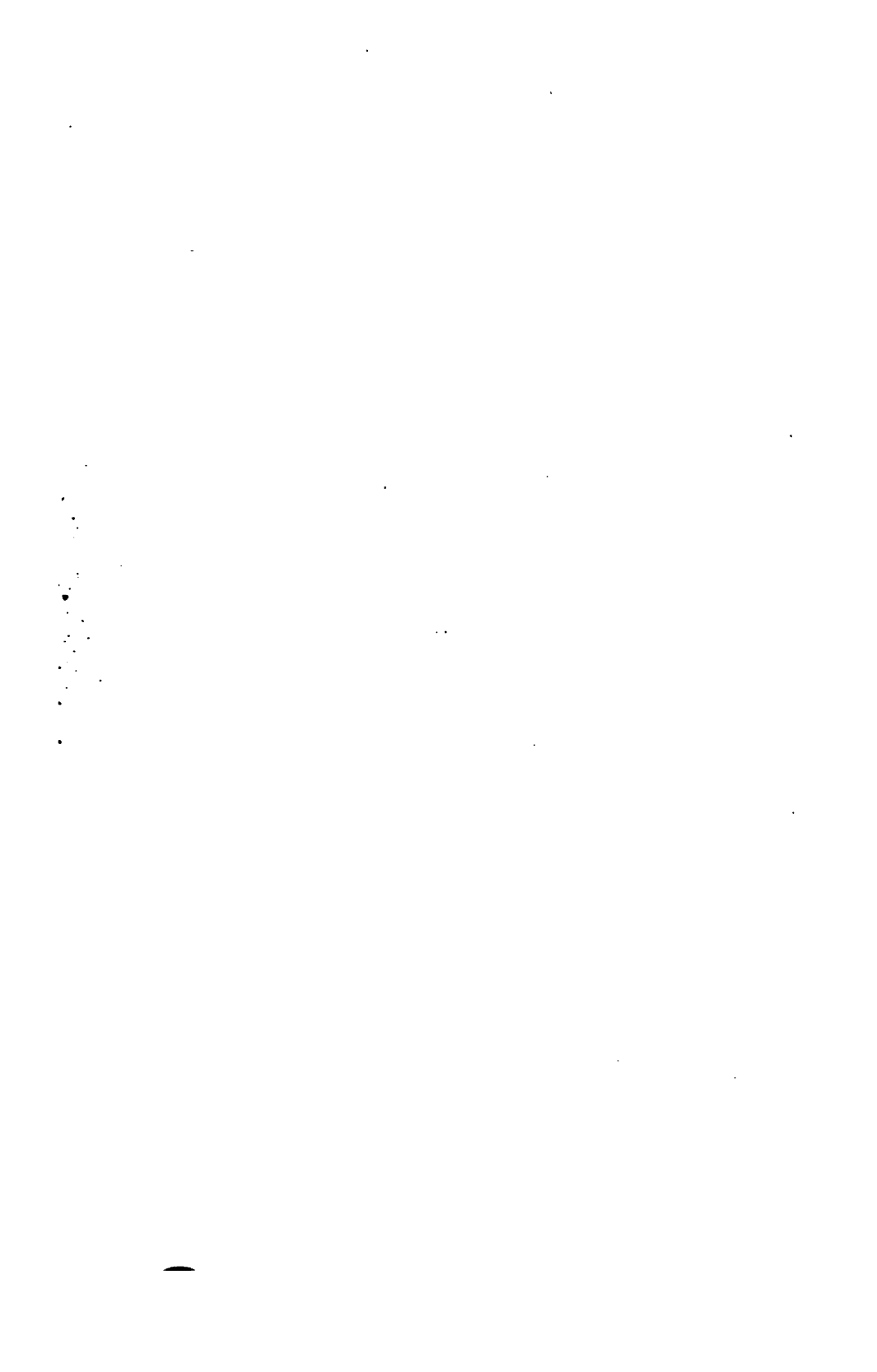
lower figure in the decimal place the entire area of the spot was taken as belonging to the degree of latitude indicated by the integral part of the number. Thus a spot at lat. 9°.5 was taken as wholly belonging to lat. 10°; but one at 9°.4 to lat. 9°.

The diagram shows in a marked manner the gradual decline in the distance from the equator of Sun-spots as the minimum is approached, and the sudden appearance of spots in high latitudes immediately after the minimum is passed and a new cycle has commenced.

Royal Observatory, Greenwich:
    1889 November 8.

Note on Solar Spots in high South Latitudes.
By Rev. S. J. Perry, D.Sc., F.R.S.

It may be well to draw attention to the spots in high latitudes that have been visible on the solar surface during the last few months. These spots were all in the southern hemisphere, and with the exception of two groups were visible only for a short period. The following table comprises those recorded at Stonyhurst:—

Date.	S. Latitude.	Longitude.	Recorded duration.
1888, Dec. 30	36°	195°	1 day
1889, June 5	29	258	1 ,,
30	40	251	2 days
Aug. 2	21·3	155 to 165	36 ,,
Sept. 7	22	149·5 to 158·5	27 ,,
Oct. 8	28·5	9·5	1 day
10	25	24·5	1 ,,

The two large groups, whose latitude was not exceptionally high, form a narrow disturbed area extending over only 15° of longitude, and might almost be reckoned as a single disturbance, the first disappearing as the latter formed. The spot in latitude 40°, which was visible in England for two days, was also observed in North America. It is among the highest on record. The exceptional observations of Capocci, Peters, and Carrington all followed the minimum epoch of Sun-spots. The present increase in the number of spots in high latitudes agrees well with recorded observations of former minima.

Note to accompany a Drawing of the Milky Way. By Otto
   Boeddicker, Ph.D., Astronomer at the Earl of Rosse's
   Observatory at Birr Castle, Parsonstown.

(*Communicated by the Earl of Rosse.*)

The drawing of the Milky Way referred to was begun by
me on October 24, 1884, and has occupied the greater part of
my time and energy ever since. It was undertaken in the belief
that an accurate representation of the galaxy, such as it appears
to the naked eye, was an astronomical desideratum, and would
be of some value for a variety of special investigations. In
answer to a suggestion from your Secretary I propose now to
give a short sketch of the history of the drawing.

First, I copied those maps of Argelander's *Uranometria
Nova*, which should contain parts of the Milky Way, with the
difference, however, that I indicated the stars by plain discs of
different diameter only, in order to approach more nearly the
actual appearance of the sky. Then, under exclusion of every
trace of extraneous light, I examined the Milky Way, and as
soon as I was satisfied that I had made out some feature, I turned
on an incandescent lamp, and, by means of the stump, I inserted
the detail observed in the map. This alternate seeing into
darkness and on white paper (covered with black spots) proved
a very great strain on the sight. Besides, as the eyes, after I
had drawn the part observed, only very gradually regained their
former sensitiveness, the work proceeded but slowly, three or
four hours' drawing representing but a very small portion of it.
As much as possible I drew the different sections only when they
were near the meridian, in order to obtain the conditions most
favourable for atmospheric transparency. This involved for the
greater part of the Milky Way the necessity of my lying flat on
my back (or nearly so) in the open air for hours together—a
position which, especially on frosty nights, proved somewhat
trying, for no amount of clothing was found sufficient to
counteract the radiation of heat from the body.

The results were verified on consecutive nights, and further
details added, so that a large number of nights was devoted to
a single section. A further control was obtained by the over-
lapping of the sections, so that large portions of the Milky Way
had to be drawn twice or even three times. This was in all cases
done directly from the sky. In fact, the separate sections were
never compared with each other until I had ceased to work at
them. Next I constructed a large chart in stereographic projec-
tion down to 100° North Polar Distance, and inserted the parts
of the Milky Way as furnished by the sections. This was
required in order to deduce a true picture of the gradation of
light in the Milky Way, or, in other words, a general uniform

standard of luminosity, for up to this stage of the work each
section, being drawn independently, contained its own standard.
This construction of a large chart was comparatively easy, since,
in consequence of the overlapping of the sections, a *tertium
comparationis* for the brightness of the different regions was
readily found.

The large map having been drawn, three different methods of
controlling the gradation of light were employed. First, the differ-
ent spots and parts of the Milky Way were numbered, and written
down directly from the sky in order of brightness, those parts
which were equal in brilliancy being specially singled out.
Next, I noticed repeatedly the order in which the different por-
tions of the galaxy appeared from first twilight to complete
darkness, and, finally, the order in which they disappeared with
the rising Moon. Some special precautions against errors had to
be taken during the two last series of observations, which, how-
ever, I have not now time to particularise.

I delayed the combination of the sections into a general chart
as long as possible, as—in order to exclude the possibility of any
preconceived idea as to the structure of the Milky Way on my
part—I wanted to remain as long as possible in ignorance of its
appearance *as a whole.* For the same reason I avoided carefully
all previous pictures; the most important of these—Heis's in his
Atlas Cœlestis Novus—I never even saw until I had finally given
up drawing. Purposely I do not say "until my drawing was
finished," for I found the difficulty of producing a picture of the
Milky Way so extremely great, that even now, after having
spent five years on it, I have not yet the sensation of having
done all I could and should have done. Yet I think that my
errors will be rather those of omission than of commission, as I
did my very best not to put down anything which I did not per-
ceive over and over again as I finally drew it. But, of course,
the hand may not always be able to follow the eye, and I appeal,
therefore, to other observers to verify or correct my drawing.

The last stage of the work consisted in the construction of
the three enlarged sections covering the whole of the Milky
Way, and the general chart as they are here exhibited. On the
latter the parallels and meridians were not indicated, as I wanted
it to contain nothing but what is actually seen in the sky. The
stars in these maps were taken from the Catalogue of the
Uranometria Nova.

It is not my object here to enter into a long discussion of my
drawing. But I may perhaps direct attention to a few special
points.

The fainter detail given in my map becomes best visible if
examined at a distance of from five to ten feet. The physio-
logical reason for this appears to be that the contrast between
the faint nebulosity and the surrounding white ground is
lessened, the larger an area of our retina is covered by the image
of this nebulosity. It would be hard to decide how far this

detail follows any special law of grouping; yet the Milky Way seems to me pretty obviously to send out feelers (as it were) to nebulæ and clusters—for instance, to the nebula in *Andromeda*, and to *Præsepe* in *Cancer*. A similar tendency exists, perhaps, with regard to brighter stars. Further, I am struck with the tendency to duplication in Section III.*—a feature of which I only became aware when the general chart was constructed, and which is certainly not the outcome of any bias on my part. The larger stars seem to be surrounded by dark spaces. This cannot be altogether due to contrast, since in all these cases I employed special precautions—such as hiding the star by a small opaque object at a considerable distance from the eye—in order to get at the real appearance of the Milky Way in its immediate neighbourhood.

A comparison of my drawing with Heis's shows a striking absence of detail in the latter, no doubt owing to the fact that Heis did not devote sufficient time to it (that not being his main object), and also in consequence of his dividing the luminosity into five distinct degrees. This proceeding is not only contrary to nature, but becomes also a positive impediment in the way of any attempted imitation of it. Heis's drawing shows a broad region of faint luminosity surrounding the Milky Way proper. This I have not tried to imitate for two reasons. First, I am not sure that this luminosity is confined to the Milky Way. On the contrary, I perceive irregular patches of faint luminosity all over the sky—or, in other words, the background of the sky does not appear to me at all uniformly black. And, secondly, an attempt at drawing this luminosity would have thrown up, as it were, my scale of gradation to such an extent that pencil alone would have been insufficient to reproduce the most intense por-·tions of the galaxy. In the same way all the lanes and rifts ought (probably with one or two exceptions) to be filled in with faint luminosity. I have tried to do this as much as possible, but may not have quite succeeded in rendering it conspicuous. Finally, I draw attention to the wisps of nebulous matter following rows of stars. It is not impossible that in some cases these wisps are due to the glare of the stars, or to irradiation on my retina ; but, of course, according to my plan, I had to draw what I perceived. But it formed a part of my original programme to re-examine the Milky Way with a low-power telescope, in order to separate the optical from the physical luminosity. I now doubt much, however, whether I shall find time to do this, and I shall probably be obliged to leave this rather promising branch of the investigation to other observers.

In concluding these somewhat desultory remarks, I must not omit to state that one of the objects in exhibiting the drawing is to elicit opinions of astronomers as to the mode to be

* [Section III. represents that portion of the Milky Way which is situated in the constellations *Perseus, Camelopardus, Taurus, Auriga, Orion, Monoceros, Gemini,* and *Canis Minor*.—Eds.]

adopted for its reproduction, and also to ask whether a cheap reproduction of the star-charts alone (without the Milky Way) would be considered of any value for observatory use. I certainly found that the existence of such charts would have saved me a considerable amount of time and labour. May I, therefore, say that I should be very grateful for any general or special criticism, as well as for advice with regard to the best way to publish the maps?

A Discussion of Greenwich North Polar Distances of Polaris and other Stars, with reference to Corrections for Temperature and Humidity. By W. Grasett Thackeray.

(*Communicated by the Astronomer Royal.*)

The following paper is a continuation of one communicated to the Society last year, which will be published in vol. xlix. of the *Memoirs*, and is an endeavour to determine whether the discordances in the observed polar distances of *Polaris* arise from an imperfect correction for changes of temperature, or from the want of a correction for variations in the amount of humidity, or from some other cause.

The discordances here dealt with are the differences in the observed places of *Polaris* and *Polaris S.P.* as compared with the means of these observations grouped according to the readings of the exterior thermometer, or according to the value of humidity as given by the actual readings of the wet and dry bulb thermometer, taken from the photographic sheets, corresponding to the dates and times at which the observations of *Polaris* and *Polaris S.P.* were made.

The discordances for temperature depend on the observations made during the two periods, 1851–67, and 1877–84, and the discordances for humidity on the years 1877–84 only.

The following discordances, arranged according to temperature, are the result of a more careful discussion of the lower and higher temperatures, and an extension of the range of temperature in the latter direction, and represent errors of zenith distance.

Temperature	$\overset{\circ}{2}5$	$3\overset{\circ}{0}\cdot5$	$\overset{\circ}{3}4$	$3\overset{\circ}{8}$	$\overset{\circ}{4}2$	$\overset{\circ}{4}6$	$\overset{\circ}{5}0$
1851–67 1877–84	$+\cdot10_{93}$	$+\cdot16_{111}$	$+\cdot14_{249}$	$+\cdot18_{393}$	$+\cdot21_{402}$	$+\cdot06_{456}$	$+\cdot08_{437}$

Temperature	$\overset{\circ}{5}4$	$\overset{\circ}{5}8$	$\overset{\circ}{6}2$	$6\overset{\circ}{7}\cdot5$	$7\overset{\circ}{2}\cdot2$	$7\overset{\circ}{7}\cdot0$	$8\overset{\circ}{3}\cdot0$
1851–67 1877–84	$+\cdot04_{398}$	$-\cdot09_{274}$	$-\cdot16_{274}$	$-\cdot32_{396}$	$-\cdot45_{130}$	$-\cdot60_{72}$	$-\cdot49_{21}$

Equating these residuals in the form A + Bt = residual, where t = temperature, and A and B constants,

$$140\,A + 6983\,B = +258''\cdot39,$$
$$6983\,A + 369721\,B = -0''\cdot97\,;$$
$$\text{Whence } A = -0''\cdot721, \text{ and } B = +0''\cdot01432\,;$$

and assuming the value of the refraction for *Polaris* as 45″, our correction to refraction becomes

$$(1) \qquad \frac{\text{Refraction}}{45}\,(0\cdot0143\,t - 0\cdot721)\,;$$

and the corrections corresponding to the above temperatures for *Polaris* are

Correction	$-'\cdot36$	$-''\cdot26$	$-''\cdot23$	$-''\cdot18$	$-'\cdot12$	$-''\cdot07$	$-''\cdot01$
Residual	$-\cdot26$	$-\cdot10$	$-\cdot09$	00	$+\cdot09$	$-\cdot01$	$+\cdot09$
Correction	$+\cdot05$	$+\cdot10$	$+\cdot17$	$+\cdot24$	$+\cdot31$	$+\cdot38$	$+\cdot47$
Residual	$+\cdot09$	$+\cdot01$	$+\cdot01$	$-\cdot08$	$-\cdot14$	$-\cdot22$	$-\cdot02$

The following discordances depend on the observations of *Polaris* and *Polaris S.P.* made during the years 1877–84, and the values of relative humidity for each observation were determined as follows :—The readings of the dry and wet bulb thermometers were taken from the meteorological records for the nearest hour to the time of meridian passage on each day of observation, and the value of the corresponding relative humidity (= "h") was then obtained from Glaisher's Hygrometrical Tables. The observations were then arranged according to the values of "h" for each year both above and below pole, and the differences between the mean of each of these groups and the mean annual value found, and these differences for each year, both above and below pole, were afterwards combined, and are as follows, representing errors of zenith distance.

Value of "h"	98	92	87	82	77	72
1877–84	$+''21_{116}$	$+''26_{139}$	$+''24_{131}$	$+''08_{123}$	$+''08_{109}$	$+''02_{98}$
Value of "h"	68	62	58	53	47	43
1877–84	$-''14_{90}$	$-''29_{106}$	$-''31_{79}$	$-''47_{34}$	$-''66_{21}$	$-''81_{13}$

Equating these residuals in the form of A + Bh = residual, where h = humidity (saturation being equal to 100), we have

$$1043\,A + 80597\,B = -5''\cdot24,$$
$$80597\,A + 6442707\,B = -3959''\cdot02.$$
$$\text{Whence } A = +1''\cdot274, \text{ and } B = -0''\cdot016558\,;$$

and our assumed correction for humidity becomes

$$(2) \qquad \frac{\text{Refraction}}{45} \, (+1\cdot27 - 0\cdot0166\,h);$$

and the corrections corresponding to the above humidities for *Polaris* are

Correction	$-{''}34$	$-{''}24$	$-{''}16$	$-{''}08$	${''}00$	$+{''}09$
Residual	$-\cdot13$	$+\cdot02$	$+\cdot08$	00	$+\cdot08$	$+\cdot11$
Correction	$+\cdot15$	$+\cdot25$	$+\cdot32$	$+\cdot40$	$+\cdot50$	$+\cdot57$
Residual	$+\cdot01$	$-\cdot04$	$+\cdot01$	$-\cdot07$	$-\cdot16$	$-\cdot24$

In order to compare the values for " h " and " t," the observations of 1877–84 were arranged according to temperature, and the values of " h " corresponding to this arrangement also found.

Temperature	$25°$	$30°$	$34°$	$38°$	$42°$	$46°$	$50°$
1877–84	$+{''}28_{16}$	$+{''}25_{36}$	$+{''}08_{36}$	$+{''}20_{131}$	$+{''}25_{147}$	$+{''}13_{141}$	$+{''}18_{136}$
" h "	82	84	87	85	84	82	81
Temperature	$54°$	$58°$	$62°$	$67°$	$72°$	$77°$	$83°$
1877–84	$+{''}08_{100}$	$-{''}36_{83}$	$-{''}28_{68}$	$-{''}45_{99}$	$-{''}60_{40}$	$-{''}78_{20}$	$-{''}64_{8}$
" h "	76	70	66	64	58	55	47

and the corresponding residuals, after applying our assumed corrections for " t " (1) and " h " (2) are

(1)	$-{''}08$	$-{''}01$	$-{''}15$	$+{''}02$	$+{''}13$	$+{''}06$	$+{''}17$
(2)	$+\cdot20$	$+\cdot14$	$-\cdot08$	$+\cdot07$	$+\cdot14$	$+\cdot05$	$+\cdot12$
(1)	$+\cdot13$	$-\cdot26$	$-\cdot11$	$-\cdot21$	$-\cdot29$	$-\cdot40$	$-\cdot17$
(2)	$+\cdot10$	$-\cdot24$	$-\cdot09$	$-\cdot23$	$-\cdot26$	$-\cdot41$	$-\cdot14$

The errors of the Sun's tabular N.P.D. for each month in the years 1877–86, corrected to one system of R — D and Bessel's refractions, and the present adopted value of colatitude for Greenwich, viz. 38° 31′ 21″·90, and furthermore reduced to represent the refractions referred to the Standard Meteorological thermometer, have been carefully computed. The means were also taken of the Standard thermometers corresponding to each group of observations to enable us to obtain a value for " t."

To obtain the value of " h " the values of the dry and wet bulb thermometer were taken from the meteorological records for each day of observation, and the corresponding value of relative humidity (" h ") was taken from Glaisher's tables, and the mean of each group taken.

	Jan.	Feb.	March.	April.	May.	June.
Tabular Errors 1877–86	+″·20	−″·20	−″·39	+″·02	+″·25	+″·24
Approx. Mean N.P.D.	111°	103°	92°	80°	72°	67°
„ Mean Refraction	190″	120″	80″	50″	40″	33″

	July.	Aug.	Sept.	Oct.	Nov..	Dec.
Tabular Errors 1877–86	+″·58	+″·33	+″·19	+″·18	+″·04	−″·26
Approx. Mean N.P.D.	68°	76°	87°	99°	108½°	113°
„ Mean Refraction	34″	45″	65″	100″	160″	210″
Temperature	38·5°	44·0°	51·5°	55·1°	63·0°	77·0°
Humidity	75	74	65	61	55	54
Temperature	72·6°	71·2°	65·0°	54·7°	45·8°	39·2°
Humidity	54	57	62	69	73	78

The residuals, after applying the corrections for "t" (1) and "h" (2), corresponding to the above temperatures and humidities are

(1) $+·91$ $+·03$ $-·46$ $-·03$ $+·09$ $-·06$ $+·34$ $+·03$ $-·11$ $+·08$ $+·25$ $+·44$

(2) $+·08$ $-·34$ $-·74$ $-·25$ $-·08$ $-·06$ $+·28$ 00 $-·16$ $-·12$ $-·21$ $-·22$

As these results were not satisfactory, and gave no assurance that either correction was an unmixed advantage, a table was made of the corrections for every 10° of zenith distance corresponding to what we assumed would be the extreme ranges of temperature and humidity for night observations, in order to see what sort of discordances might be expected to show themselves in the observations of the stars. The extreme temperatures were assumed to be 65° and 25°, and the extreme humidities 100 and 50. The following is the table:—

Zen. Dist.	Approx. Mean Refraction.	Temperature. 65°	Temperature. 25°	Relative Humidity. 100	Relative Humidity. 50
60°	100″	+0·5″	−0·7″	−0·8″	+0·9″
70	160	0·7	1·3	1·3	1·5
80	320	1·5	2·5	2·6	3·1
81	350	1·7	2·8	2·9	3·5
82	390	1·9	3·2	3·3	4·0
83	440	2·1	3·5	3·8	4·4
84	500	2·3	4·0	4·0	4·9
85	590	2·7	4·6	4·7	5·8
86	700	+3·2	−5·6	−5·6	+6·8

We then determined to see what effect these corrections would have on the observations of low southern stars, and the answer is apparently decisive. The observed places will allow of neither the one nor the other correction, but they show that the refractions of the Fundamenta give more satisfactory results than those of the Tabulæ, as also that any correction due to humidity is exceedingly small.

Taking the observations of low southern stars of Z.D. 82° 50′ and upwards for the years 1876–86, and correcting each daily result for R — D, colatitude and refraction, the same as for the mean places in the Greenwich 1880 Catalogue, and taking the assumed place, annual precession, and proper motion from the Cape 1880 Catalogue (Stone), we have called the difference between the observed places at Greenwich and the Cape, error of refraction at Greenwich. The mean Z.D. of all the stars used is 85°·½.

Taking the reading of the thermometer used in the reductions of each observation from the volume of Greenwich observations we have corrected these errors of refraction for our assumed law of correction for temperature (1) and arranged the errors in order of temperature, also giving the corrected errors for the corresponding humidities.

Taking the readings of the dry and wet bulb thermometers for the nearest half hour to the time of meridian passage of each star from the meteorological records we have found the relative humidities ("h") from these data, and corrected these errors of refraction according to our assumed law (2) for correction for humidity, and arranged the errors in order of humidity, also giving the corrected errors for the corresponding temperatures.

Finally we have diminished the log mean refractions of the Tabulæ for all observations above 85° Z.D. by ·00143 in order to show the errors of refraction as given by Bessel's Fundamenta, and the corresponding errors of refraction are given in each table.

TABLE I.

Temperature.		No. of Observations.		Error of Refraction (Tabulæ).		Error of Refraction (Tabulæ). Corrected for Temperature.		Error of Refraction (Tabulæ). Corrected for Humidity.		Error of Refraction. Fundamentals.	
31°5	35°3	11	31	+3·74	+2·65	+0·39	−0·57	+2·11	+0·16	+1·37	+0·68
37·4		20		+2·04		−1·10		−0·91		+0·30	
42·0	45·9	20	66	+3·00	+2·43	+0·29	+0·46	+1·16	+0·43	+1·38	+0·86
47·5		46		+2·21		+0·54		+0·11		+0·64	
52·7	55·5	49	95	+1·32	+1·53	+0·60	+1·63	−0·36	+0·33	−0·35	−0·18
56·8		32		+1·19		+1·49		−0·11		−0·34	
64·6		14		+2·96		+5·60		+3·72		+0·78	

TABLE II.

Humidity.		No. of Observations.		Error of Refraction (Tabulæ).		Error of Refraction (Tabulæ). Corrected for Humidity.		Error of Refraction (Tabulæ). Corrected for Temperature.		Error of Refraction. Fundamentals.	
97	93	13	58	+2·47	+2·09	−2·07	−1·70	+1·13	+0·63	+0·90	+0·28
92		45		+1·98		−1·64		+0·49		+0·10	
86	85	52	87	+1·76	+2·10	−0·28	+0·43	+0·27	+0·72	+0·23	+0·50
82		35		+2·73		+1·64		+1·77		+0·91	
75	73	36	45	+1·59	+1·74	+2·53	+3·05	+1·12	+1·67	−0·31	−0·13
65		9		+2·31		+5·14		+3·89		+0·60	

The mean error of refraction (Tabulæ) given by the stars below 85° Z.D. is + 1″·00 depending on 72 observations.

We now assume that the discordances are not connected with the correction for refraction, that they are still due to temperature, and probably closely connected with changes in the instrument itself, and that they vary as the sin Z.D. Our correction for temperature then becomes

$$(3) \quad \frac{\sin z}{\sin 38°·31}(0''·0143\, t - 0''·721) = \sin z\,(0''·0230\, t - 1''·158),$$

and the following table represents the corrections to the low southern stars :—

Temperature		No. of Observations		Error of Refraction (Tabulæ).		Error of Refraction Fundamenta.		Tabulæ Corrected. $(-1''·158 + ''·0230\,t)\sin z.$		Fundamenta Corrected $\sin z.$	
°				″	″	″	″	″	″	″	″
31·5		11		+3·74		+1·37		+3·30		+0·93	
37·4	35·3	20	31	+2·04	+2·65	+0·30	+0·68	+1·72	+2·28	−0·02	+0·32
42·0		20		+3·00		+1·38		+2·80		+1·18	
47·5	45·9	46	66	+2·21	+2·43	+0·64	+0·86	+2·12	+2·34	+0·55	+0·74
52·7		49		+1·32		−0·35		+1·35		−0·32	
56·8	55·5	32	95	+1·19	+1·53	−0·34	−0·18	+1·32	+1·62	−0·21	−0·08
64·6		14		+2·96		+0·78		+3·26		+1·08	

The residuals, after applying this correction (3) to the errors of tabular N.P.D. of the Sun, as given above, are

January.	February.	March.	April.	May.	June.
$+{\cdot}51$	$+{\cdot}03$	$-{\cdot}32$	$+{\cdot}02$	$+{\cdot}10$	$-{\cdot}20$

July.	August.	September.	October.	November.	December.
$+{\cdot}22$	$-{\cdot}06$	$-{\cdot}08$	$+{\cdot}18$	$-{\cdot}24$	$+{\cdot}06$

The mean error for the year being now $+'''{\cdot}01$ instead of $+'''{\cdot}10$.

These results are more satisfactory, and seem to point to a probable explanation of R — D. The case seems to stand thus : here is a star constantly observed throughout the year, and the observations, when tabulated according to temperature, give marked discordances with a range of nearly $1''$. First of all, assuming that these discordances were due to either a defective temperature correction, or to the want of a correction for humidity, it has been shown that the observations of low southern stars not only do not require such a correction, but apparently demonstrate that there is little or no fault to be found with the refractions in this respect ; and, secondly, assuming that this temperature correction is also instrumental, and varies as sin Z.D., it is further shown that such a correction, applied to the observations of low southern stars, and to the tabular errors of the Sun, in both cases, gives satisfactory results. The same stars, observed both by direct view and also by reflexion from mercury, show large and varying discordances which are tabulated as R — D according to zenith distance, and are supposed to be applicable half to the R observation and half to the D observation, though there has never been any direct proof of the truth of this arrangement, and a correction is computed from a formula A + B sin z, when A and B are constants determined yearly from the observed R — D. Now these discordances in the direct observations of *Polaris* appear to also conform themselves to the same formula, and to be also applicable as corrections to other observations, and it would, therefore, be fair to assume that R — D was entirely an instrumental correction, and should contain a term depending on temperature. The importance of such a correction in the cases of the Sun and Moon, which are observed at very extreme temperatures in the course of the year, needs no demonstration.

The following table represents the mean Z.D.'s of each group of R — D stars for the year 1887, the mean thermometer reading used in the reductions, the correction required by our assumed temperature formula sin z $(0{\cdot}0460\ t - 2{\cdot}316)$ as applicable to R — D, and the difference between the observed value of R — D, and the value computed by the formula $-''{\cdot}06 + 1{\cdot}365$ sin z in use for that year.

The result of applying the assumed temperature correction is to diminish the sum of the squares of the residuals from $5'''{\cdot}56$ to $4''{\cdot}71$.

Table of Assumed Temperature Correction to Groups of R − D, 1887.

Mean Z. D. South.	Mean Temp.	Assumed Temperature Correction.	Error of Ordinary formula.	Corrected Error.	Mean Z. D. South.	Mean Temp.	Assumed Temperature Correction.	Error of Ordinary Formula.	Corrected Error.
−67 12	43·1	+·31	−1·13	−·82	+12·11	43·0	−·07	−·19	−·26
65 27	42·7	+·31	−0·95	−·64	19·50	46·8	−·05	+·02	−·03
63 19	42·4	+·32	+ ·28	+·60	24·16	46·4	−·08	−·02	−·10
62 21	46·7	+·14	− ·01	+·13	27·31	45·7	−·09	+·14	+·05
59 4	45·5	+·18	+ ·23	+·41	31·1	45·0	−·12	+·36	+·24
55 43	50·5	00	+ ·23	+·23	33·28	45·0	−·13	+·39	+·26
51 41	46·8	+·12	− ·27	−·15	37·38	51·2	·00	−·02	−·02
47 30	39·6	+·33	− ·02	+·32	40·58	46·4	−·13	−·24	−·37
41 18	48·4	+·07	− ·17	−·10	43·38	43·0	−·23	−·01	−·24
35 28	45·8	+·11	− ·11	·00	46·46	51·6	+·05	+·24	+·29
30 15	45·4	+·12	− ·09	+·03	49·2	45·7	−·15	−·07	−·22
25 52	48·3	+·04	+ ·25	+·29	52·23	51·0	00	+·05	+·05
21 26	44·3	+·10	+ ·12	+·22	56·23	48·2	−·08	−·41	−·49
16 12	42·8	+·06	+ ·55	+·61	60·48	42·1	−·33	−·66	−·99
13 13	50·9	00	+ ·37	+·37	62·11	61·2	+·44	−·40	·00
− 9 59	45·3	+·04	− ·46	−·42	65·5	34·5	−·68	+·86	+·18
					+67·13	52·4	+·08	−·62	−·54

The results we may sum up as follows :—The effect on refraction due to humidity, if any, is exceedingly small. A correction depending on temperature, and varying as sin *z*, will satisfy the discordances in the observations of *Polaris*, it will get rid of an annual variation, also apparently depending on temperature, in the tabular errors of the Sun ; as far as it goes it will tend to bring in greater accordance the errors derived from low southern stars when arranged in order of temperature, and it will diminish the sum of the squares of the residuals of the R − D formula. Each of these results being a link in a chain partaking of the nature of circumstantial evidence.

Results of Double-Star Measures at Windsor, New South Wales, during the Years 1886, 1887, *and* 1888. By John Tebbutt.

This communication comprises all the double-star results obtained here during the years 1886, 1887, and 1888. All the measures were made with the eight-inch equatorial, except those of *a Centauri*, on July 27 and August 6, 1886, which were made with the 4½-inch instrument. The column headed "Hour Angles" contains the hour-angles between which each set of measures was taken, and the last column gives the weight assigned from a consideration of the conditions under which the observations were made. 1 denotes an unusually bad condition, and 5 an unusually good one.

No.	Star.	Observed Magnitude.	Approx. Place for beginning of Year. R.A. (h m)	Dec. S. (° ′)	Date of Obs.	Position Angle. °	No. of Obs.	Distance.	No. of Obs.	Mag. Power.	Hour Angle. (h m)	Hour Angle. (h m)	Weight.
1	p Eridani	...	1 36	56 46	1887·121	232·3	10	6″·89	7	170	4 0 W	5 0 W	...
2	„	6, 6	„	„	1887·131	231·4	10	6·90	8	170	5 4 W	5 40 W	3
3	„	...	„	„	1887·734	230·7	10	...	...	230 }	4 45 E	4 24 E	...
4	„	...	„	„	1887·734	230·7	10	...	...	300 }	3 23 E	2 52 E	...
5	„	6, 6	„	„	1887·747	229·5	10	6·91	10	300	0 52 W	1 26 W	4
6	„	6, 6	„	„	1887·934	228·5	10	7·27	10	230	3 51 W	4 24 W	4
7	„	6, 6	„	„	1888·038	228·1	10	6·66	10	300	1 0 E	0 21 E	3
8	Lac. 2145	...	6 2	48 27	1887·104	26·3	10	2·07	7	170	2 11 W	3 14 W	3
9	„	8, 8¼	„	„	1887·205	24·0	10	...	...	170	3 16 E	2 44 E	...
10	„	...	„	„	1887·942	22·2	10	1·84	10	300	4 11 W	4 25 W	...
11	V Puppis	6¾, 8	6 36	48 7	1888·288	...	...	13·39	5	...	1 53 E	1 19 E	3
12	Lac. 2640	...	7 2	59 1	1887·134	85·1	10	2·38	7	...	3 10 W	3 26 W	3
13	„	6½, 7½	„	„	1888·288	...	...	2·51	5	130	2 8 W	2 42 W	4
14	γ Piscis Vol.	4, 6	7 10	70 19	1888·288	...	...	13·28	5	170	0 14 W	0 45 W	2
15	„	...	„	„	1888·304	299·7	10	...	...	300	3 20 W	3 40 W	4
16	γ Argûs A.B.	...	8 6	47 0	1887·356	220·3	6	41·16	5	...			3
17	„ „ A.B.	2, 5	„	„	1888·301	...	...	41·77	5	130 }			3
18	„ „ A.O.	2, 7½	„	„	1888·301	...	...	62·32	5	130 }	1 13 W	2 12 W	3
19	„ „ A.D.	2, 8	„	„	1888·301	...	...	92·59	5	130 }			3

No.	Star.	Observed Magnitude.	Approx. Place for beginning of Year. R.A. (h m)	Dec. S. (° ')	Date of Obs.	Position Angle.	Distance.	No. of Obs.	No. of Obs.	Mag. Power.	Hour Angles (h m)	Hour Angles (h m)	Weight.
20	γ Argûs A.B.	2, 5	8 6	47 0	1888·301	220·4	″ ...	5	...	140			3
21	" A.C.	2, 7½	"	"	1888·301	151·2	...	5	...	140	2 12 W	3 0 W	3
22	" A.D.	2, 8	"	"	1888·301	141·6	...	5	...	140			3
23	h 4087	8, 8¼	8 18	40 40	1887·345	298·6	1·85	10	5	170	3 33 W	5 14 W	3
24	"	...	"	"	1887·350	300·8	...	10	...	170	3 3 W	3 35 W	4
25	Lac. 3366	6, 9	8 26	44 21	1887·134	348·0	4·51	10	8	...	2 28 E	1 36 E	3
26	h 4306	7, 7	10 16	64 7	1887·134	138·4	1·89	10	3	...	2 54 E	2 19 E	3
27	Σ 1500	8½, 8¾	10 54	2 55	1887·131	311·7	1·71	10	5	170	3 1 E	2 20 E	3
28	h 4432	7, 8½	11 19	64 20	1888·320	298·6	...	10	...	300	1 20 E	1 1 E	4
29	"	8, 9	"	"	1888·323	...	2·23	...	8	170	2 12 E	1 55 E	4
30	h 4507	9, 10	12 8	44 16	1888·320	222·6	...	10	...	140	2 43 E	2 30 E	4
31	"	9, 10	"	"	1888·323	...	16·47	...	7	170	2 32 E	2 2 E	4
32	"	8, 9	"	"	1888·342	223·3	...	10	...	140	0 55 E	0 20 E	...
33	α Crucis	...	12 20	62 28	1887·104	115·8	5·19	10	6	170	3 52 E	3 27 E	3
34	"	1½, 1¼	12 20	62 29	1888·320	120·4	...	10	...	230	1 49 E	1 26 E	4
35	"	...	"	"	1888·323	...	4·73	...	10	170	5 29 E	5 4 E	4
36	Lac. 5147	...	12 20	62 29	1888·323	...	89·96	...	5	170	4 53 E	4 38 E	4
37	"	1¾, 5	"	"	1888·320	202·0	...	10	...	230			4
38	"	...	"	"	1888·323	...	89·87	...	5	170	4 38 E	4 26 E	4

No.	Star.	Observed Magnitude.	Approx. Place for beginning of Year. R.A. (h m)	Dec. S. (° ')	Date of Obs.	Position Angle.	No. of Obs.	Distance.	No. of Obs.	Mag. Power.	Hour Angles. (h m)	(h m)	Weight.
39	δ Corvi	3½, 8	12 24	15 54	1888·208	214·9	5	24·11	5	130	3 20 E	2 45 E	3
40	γ Centauri	...	12 35	48 20	1887·580	359·6	8	...	...	300	4 24 W	4 40 W	3
41	"	4, 4	"	"	1887·586	358·5	10	1·76	7	300	3 4 W	3 30 W	3
42	"	4, 4	12 35	48 21	1888·219	0·4	10	1·56	5	170	3 41 E	3 10 E	4
43	"	4, 4	"	"	1888·320	...	...	1·80	10	170	3 21 E	3 4 E	3
44	"	...	"	"	1888·329	...	...	1·60	6	170	5 6 E	4 54 E	3
45	"	...	"	"	1888·329	359·3	10	1·79	6	...	4 47 E	4 21 E	3
46	"	...	"	"	1888·340	358·5	10	1·88	8	300	4 42 E	4 16 B	3
47	"	...	"	"	1888·605	...	...	2·73	8	130	4 16 W	4 30 W	2
48	"	...	"	0 50	1888·608	359·7	10	...	...	300	5 30 W	5 44 W	3
49	γ Virginis	4, 4	12 36	0 50	1887·386	155·5	10	5·61	10	300	1 49 E	1 10 E	3
50	"	4, 4	"	"	1887·386	155·5	10	5·69	10	300	1 7 W	1 55 W	2
51	"	...	"	"	1888·329	156·4	10	5·68	8	300	1 15 E	0 33 E	3
52	"	...	"	"	1888·635	153·3	12	5·86	8	300	2 40 W	3 15 W	4
53	β Muscae	4, ...	12 39	67 30	1888·334	329·4	10	1·33	8	300	2 55 E	2 51 E	3
54	"	...	"	"	1888·340	329·2	10	1·18	5	...	2 47 E	2 19 E	3
55	Sydney, 213	8, 8	13 1	59 16	1888·334	261	10	0·7	...	300	2 11 E	1 59 E	3
56	Lac. 5632	7, 8½	13 35	53 59	1888·326	...	...	5·21	10	170	2 53 E	2 30 E	5
57	"	...	"	"	1888·329	163·6	10	5·23	5	300	3 23 E	2 48 E	4, 1

No.	Star.	Observed Magnitude.	Approx. Place for beginning of Year. R.A.	Dec. S.	Date of Obs.	Position Angle.	No. of Obs.	Distance.	No. of Obs.	Mag. Power.	Hour Angles.		Weight.
			h m	° '		°		"			h m	h m	
58	Sydney₁₁ 411	...	13 41	61 33	1888·323	...	...	12·27	8	170	2 50 E	2 12 E	4
59	λ 4634	8¾, 10	13 50	55 29	1888·326	...	...	12·19	10	170	3 55 E	3 28 E	4
60	" "	8¾, 10	"	"	1888·329	16·6·	10	12·29	10	{230/140}	4 47 E	4 2 E	4
61	" "	8¾, 9½	"	"	1888·340	13·7	10	12·65	6	140	3 9 E	2 38 E	4
62	" "	...	"	"	1888·364	16·0	12	12·29	6	140	2 49 E	2 18 E	...
63	" "	...	"	"	1888·605	...	...	12·68	7	130	3 56 W	4 18 W	4
64	" "	8, 9	"	"	1888·608	14·4	10	12·27	5	140	3 24 W	3 54 W	3
65	λ 4630	8¾, 8¾	13 51	65 5	1888·342	314·1	10	4·18	7	{230/140}	3 43 E	3 14 E	...
66	α Centauri	1, 3	14 32	60 22	1886·567	200·8	10	15·30	10	...	1 23 E	0 48 E	4
67	"	1, 3	"	"	1886·567	202·9	10	15·48	10	...	0 33 W	1 5 W	3
68	"	1, 3	"	"	1886·594	199·9	10	14·84	10	180	2 18 E	1 46 E	3
69	"	1, 3	"	"	1886·594	203·8	10	15·22	10	180	...	1 47 W	3
70	"	...	"	"	1886·613	201·4	8	15·08	8	170	...	...	3
71	"	...	"	"	1886 613	202·0	5	15·65	5	170	...	1 48 W	1
72	"	...	"	"	1886·627	202·1	9	15·13	9	170	1 57 W	2 35 W	2
73	"	...	"	"	1886·646	201·2	5	14·90	5	170	5 52 W	6 21 W	2
74	"	...	"	"	1887·326	201·9	10	15·98	6	170	2 45 E	1 59 E	5
75	"	1, 2	"	"	1887·345	201·4	10	16·05	6	170	0 34 E	0 6 W	3
76	"	1, 2	"	"	1887·356	202·4	10	15·87	10	300	1 37 E	1 10 E	3
77	"	1, 2	"	"	1887·356	203·4	10	16·06	10	300	1 5 W	1 39 W	3

No.	Star.	Observed Magnitude.	Approx. Place for beginning of Year. R.A.	Dec. S.	Date of Obs.	Position Angle.	No. of Obs.	Distance.	No. of Obs.	Mag. Power.	Hour Angle.		Weight.
			h m 14 32	° ′ 60 22		°					h m	h m	
78	α Centauri	...	14 32	60 22	1887.479	202.3	10	...	...	300	1 13 W	1 27 W	4
79	"	...	"	"	1887.482	...	...	16.35	10	300	0 6 W	0 35 W	3
80	"	...	"	"	1887.575	202.1	10	16.36	7	230	3 34 W	4 0 W	2
81	"	...	"	"	1887.597	202.0	8	...	...	230	1 38 E	1 24 E	...
82	"	...	"	"	1887.597	202.4	10	16.20	10	230	1 1 E	0 36 E	...
83	"	...	"	"	1887.646	202.9	10	...	...	300	0 34 E	0 22 E	4
84	"	1, 2	"	"	1887.712	201.2	10	16.01	10	230	4 5 E	3 19 E	3
85	"	1, 2	"	"	1887.712	202.4	10	16.10	10	230	0 7 W	0 47 W	4
86	"	...	"	"	1887.712	203.1	10	16.11	10	230	4 50 W	5 29 W	4
87	"	...	"	"	1887.734	202.5	10	16.42	10	230	4 30 E	3 55 E	3
88	"	...	"	"	1887.734	201.7	10	...	...	230	2 52 E	2 41 E	3
89	"	...	"	"	1887.734	202.6	10	16.28	10	230	0 13 W	0 54 W	3
90	"	...	"	"	1887.734	201.6	12	...	...	230	2 38 W	2 55 W	3
91	"	1, 3	"	"	1888.219	204.4	10	16.89	6	170	4 55 E	4 23 E	3
92	"	...	"	"	1888.320	203.3	10	...	...	...	3 28 E	3 12 E	4
93	"	...	"	"	1888.323	...	...	16.97	8	170	4 8 E	...	3
94	"	1, 1½	"	"	1888.340	202.8	10	16.74	5	300	3 14 E	2 51 E	2
95	"	...	"	"	1888.633	...	...	17.13	5	300	4 0 E	3 20 E	...
96	"	...	"	"	1888.633	203.1	7	...	...	300	3 10 E	3 2 E	3
97	"	...	"	"	1888.633	203.0	10	16.92	8	300	0 36 E	0 5 E	3
98	"	...	"	"	1888.633	202.7	10	17.32	8	300	3 16 W	3 44 W	2

No.	Star.	Observed Magnitude.	Approx. Place for beginning of Year. R.A. h m	Dec. S. ° ′	Date of Obs.	Position Angle.	No. of Obs.	Distance.	No. of Obs.	Mag. Power.	Hour Angles. h m	h m	Weight.
99	π Lupi	...	14 58	46 37	1888·654	86·3°	10	1·50″	5	300	3 33 W	3 58 W	3
100	Lac. 6477	7, 7	15 38	65 5	1887·356	153·4	10	2·36	8	300	1 46 E	1 21 E	3
101	,,	7, 7	,,	,,	1887·706	154·2	10	2·44	6	300	3 36 W	4 10 W	3
102	,,	7, 7	,,	,,	1888·652	148·2	10	2·19	1	300	1 22 W	1 46 W	2
103	,,	7, 7	,,	,,	1888 652	148·2	10	...	...	300	1 46 W	1 56 W	4
104	,,	7, 7	,,	,,	1888·654	150·5	10	2·37	5	300	2 24 W	2 44 W	3
105	ξ Lupi	6, 6½	15 50	33 38	1887·356	50·0	10	10·69	8	300	1 16 E	0 37 E	4
106	,,	6, 6½	,,	,,	1887·706	48·3	10	10·51	8	300	4 9 W	4 41 W	3
107	η Lupi	5, 9	15 53	38 4	1887·575	19·9	10	15·36	7	230	4 50 W	5 18 W	3
108	β Scorpii	...	15 59	19 30	1887·597	24·2	10	13·71	10	300	1 11 W	1 57 W	3
109	,,	3, 7	,,	,,	1887·597	24·9	10	13·82	10	300	1 43 E	1 14 E	5
110	Brisb. 5784	8, 8	16 33	60 42	1888·643	115·7	10	2·98	6	140	2 38 W	3 6 W	3
111	,,	8, 8	,,	,,	1888·649	115·3	10	2·71	5	140	0 59 W	1 24 W	4
112	Sydney₂ 287	8, 8	16 51	58 40	1888·649	129·8	10	2·89	5	140	2 0 W	2 22 W	4
113	36 Ophiuchi	6, 6	17 8	26 26	1887·531	199·1	10	4·64	8	300	1 26 E	0 32 E	5
114	,,	...	,,	,,	1887·701	196·6	10	4·59	8	300	3 12 W	3 41 W	3
115	Lac. 7267	7, 7½	17 19	45 44	1887·695	265·3	10	2·70	8	300	4 3 W	4 29 W	5
116	λ 5027	9, 10	18 4	54 22	1887·742	97·2	12	...	...	140	2 50 W	3 17 W	5
117	,,	9, 10	,,	,,	1887·742	97·6	12	...	...	140	3 56 W	4 22 W	...
118	,,	9, 10	,,	,,	1887·767	97·4	10	11·84	4	140	3 47 W	4 25 W	...
119	κ Cor. Aust.	6, 7	18 26	38 48	1887·695	358·7	10	21·51	10	230	2 12 W	2 44 W	5

No.	Star.	Observed Magnitude.	Approx. Place for beginning of Year. R.A. (h m)	Dec. S.	Date of Obs.	Position Angle.	No. of Obs.	Distance.	No. of Obs.	Mag. Power.	Hour Angles.		Weight
120	Lac. 7924	8, 8	18 53	63 57	1887·597	292·7	10	2·10	10	300	2 15 E	1 38 E	4
121	"	8, 8	"	"	1887·709	291·7	10	2·15	5	230	1 22 W	1 44 W	4
122	Brisb. 6556	5, 5	18 53	37 13	1887·767	282·2	10	12·71	7	140	3 49 W	4 16 W	5
123	"	7, 7	"	"	1888·643	280·8	8	12·76	5	230	1 32 E	1 9 E	3
124	γ Cor. Aust.	5½, 5½	18 59	37 13	1887·712	197·6	15	1·68	8	300	1 28 W	2 2 W	3
125	"	5½, 5½	"	"	1887·715	197·8	15	...	...	300	0 59 W	1 35 W	3
126	"	5½, 5½	"	"	1887·717	194·7	12	...	...	300	2 27 W	2 50 W	5
127	"	...	"	"	1887·767	194·7	10	...	...	300	4 16 W	4 27 W	4
128	"	...	"	"	1888·307	192·4	10	1·59	7	{300/170}	2 49 E	2 8 E	5
129	"	...	"	"	1888·633	189·6	10	1·73	5	300	3 31 E	3 9 E	4
130	"	...	"	"	1888·633	185·6	10	...	...	300	1 42 E	1 26 E	3
131	"	...	"	"	1888·638	189·4	12	...	...	300	1 40 E	1 26 E	5
132	"	6, 6	"	"	1888 643	186·8	10	1·82	7	300	2 7 E	1 47 E	3
133	"	...	"	"	1888·805	191·9	12	...	...	300	1 33 W	1 50 W	5
134	Lac. 8443	7½, 7½	20 28	75 44	1887·586	16·0	10	17·92	10	230	2 37 E	2 6 E	3
135	Lac. 8550	7, 7	20 42	62 51	1887·643	94·7	10	2·94	8	{300/230}	1 28 E	0 48 E	4
136	Lac. 8687	8½, 7½	21 2	55 2	1887·709	124·8	12	3·08	5	230	1 45 E	1 12 E	...
137	θ Indi	6, 7½	21 12	53 55	1887·643	287·2	10	4·62	8	230	1 8 E	0 39 E	4
138	θ Gruis	5, 8	23 1	44 8	1887·717	22·1	10	2·33	8	300	3 5 E	2 34 E	5
139	h 2167	7, 7½	23 1	51 18	1887·717	258·9	10	8·33	6	300	0 23 E	1 53 E	5

Remarks.

1. Stars exactly equal.   2. Impossible to decide which was the brighter.   5. North component the brighter.

6, 7. Components equal.   8. Components not quite equal.   10. South star the brighter.   14. Primary yellowish, companion blue.

17, 18, 19, 20, 21, 22. The distances were determined from the observed position-angles and differences of declination.

23. Distance observed with difficulty. Herschel's position-angle in 1837 = 146°·6, Hargrave's in 1879 = 308°·9.

24. Obviously a binary system.   25. Sydney measures of distance very discordant.   26. Probably identical with Stone 5639.

27. Distance difficult to observe.   30. Components very neatly defined.   31. Primary pink, companion blue.

34. Components equal.   35, 36, 38. Observations about sunset.   40, 42. Components equal.

43. Components equal, and observed without illumination.   44, 45. Observed without illumination.

46. Components equal; measures about sunset.   52. Components equal.   53. Elongated with a power of 140, just divided with 230, and well divided with 300. Components equal.   55. Components equal; distance estimated.

57. Images steady and well defined during position measures, but definition bad and images dancing during distance measures.

59, 60, 61. Primary white and companion blue. Certainly a binary. See Cape and Sydney measures.

65. The following and south component probably the brighter.   66, 68. Daylight observations.

74. Reduced to points of light by cloud, and well observed.   81, 82, 83. Observations before sunset.

84, 85. Distances determined from position-angles and differences of declination.   87, 88, 89, 90. Observed in daylight.

95. Distance determined from position-angle and difference of declination.   99. Components equal; easily divided with a power of 230, but distance difficult to determine.   109. Observed in twilight.

101, 103. Components equal.

110. A neat double; preceding component probably the brighter. Observed at Sydney as follows: $1871 \cdot 604$, mags. 6½ and 7, P = 124°·1, D = 3″·80; $1880 \cdot 630$, mags. 10 and 10, P = 297·8, D = 2″·82.   111, 112, 113. Components equal.

114. North component slightly the brighter.   116, 117. Companion very faint.   120. The haziness which characterised this star in 1885 not now seen. In 1885 the components were equal, but now the following star is the brighter.

121. Components equal and well defined.   122. The following component perhaps the brighter.   123. Components equal.

124. Components equal, and distance observations difficult.   125, 126, 127. Components equal.   132. Components equal and hazy.

136. Components equal; distance measures difficult.   137. Companion pale blue.   138. Primary white; companion pale blue.

Private Observatory, Windsor, N. S. Wales:
    1889, *September* 25.

On the Proper Motion of the Double Star South 503.
By J. E. Gore.

Assuming that the change of position in the close pair is due to uniform rectilinear motion, I have computed the following formulæ :—

$$\rho^2 = 5\cdot76 + 0\cdot4225\,(t - 1885\cdot75)^2$$
$$\sec(\theta - 48°\cdot04) = 0\cdot4166\rho.$$

The following is a comparison between the recorded measures and the positions computed from the above formulæ. The observed position-angles have been corrected for the effect of precession to 1880·0.

Epoch.	Observer.	θ_o	θ_c	$\theta_o - \theta_c$	ρ_o	ρ_c	$\rho_o - \rho_c$
		°	°	"	"	"	"
1825·07	South	134·41	133·61	+0·80	39·94	39·57	+0·37
1873·93	Dembowski	120·13	120·69	−0·56	8·08	8·05	+0·03
1875·21	,,	118·63	118·74	−0·11	7·07	7·26	−0·19
1875·88	,,	117·52	117·52	0·0	6·72	6·85	−0·13
1881·18	Burnham	99·29	98·54	+0·75	3·58	3·82	−0·24
1882·16	,,	92·39	91·24	+1·15	3·28	3·34	−0·06
1883·11	,,	82·58	82·59	−0·01	2·90	2·95	−0·05
1887·039	Tarrant	30·36	31·09	−0·73	2·83	2·54	+0·29

The proper motion of the brighter star is, therefore, $0''\cdot60$ per annum in the direction of position-angle $138°\cdot04$.

Note on the Bright Line Spectra of R Andromedæ and R Cygni, and on the suspected Bright Lines in R Cassiopeiæ, and on the Spectrum of W Cygni. By the Rev. T. E. Espin.

On the night of September 25 the $17\frac{1}{4}$-inch was turned on R *Andromedæ*, and, although the star should have been at its maximum at the end of July, it was found to have a magnitude of about 6·5. On examining the spectrum the F line was found immediately to be bright. The brightness of this line was so extraordinary that it appeared to extend outside the spectrum. Another bright line, presumably D_3, was also observed, and near this place the spectrum seemed to consist of several very fine bright lines. The spectrum had the usual prominent bands of the third type, but far in the violet glimpses were caught of a very large and obscure band. Unfortunately the sky clouded up before the spectrum could be thoroughly examined. No other chance of examining the spectrum occurred until October 17. The star had now greatly faded, and was estimated at 7·8 mag.

It showed the usual third-type spectrum, and the F line was not certainly seen. At times it was suspected, but it had evidently decreased in brightness at a greater rate than the other parts of the spectrum.

R Cygni was examined on several nights, but the F line, if still bright, had nothing of the brilliancy which made the star such a remarkable object at the last maximum.

R Cassiopeiæ was examined on the night of September 25, and the magnitude was estimated at 7·3. It showed the usual third-type spectrum, but the bands are of remarkable size and intensity. Occasionally D_3 and the γ line of hydrogen were suspected bright, but not F.

W Cygni=Birm. 587=D.M.+44°·3877 was examined on the night of November 2 in strong moonlight. The usual third-type spectrum was seen, but no bright lines were suspected.

The Colours of Stars.   By F. W. Levander.

In the course of certain investigations it became necessary to obtain a somewhat accurate estimate of the proportions of different colours exhibited by star-discs. As I am not aware of the existence of any statistics of a similar nature, the following table may possess some little interest for observers of coloured stars. It contains particulars of the tints, as described by various observers, of 4984 stars (arranged according to their magnitudes), which are to be found in the following catalogues:—

Chambers's Catalogue of Red Stars (*M. N.*, xlvii. 352)	...	504
Franks's M.S. Catalogue of 1730 Stars		1399
Herschel's Cape Observations		134
Tupman's Southern Stars (*M. N.*, xxxiii. 312)	... ...	91
Webb's Celestial Objects for Common Telescopes, 4th edition		2856

All observations in which any discordance appears have been rejected; in some instances the want of agreement was so marked as to lead one to imagine that the important factors of aperture and kind of telescope used must be answerable for at least some of the differing statements. It is also a well-established fact—but one not always sufficiently attended to by telescopists—that the education of the colour-sense is much neglected, especially in the case of our own sex. To avoid prolixity many of the similar tints have been grouped together.

No attempt has been made to discriminate between magnitudes beyond mag. 8. The same scale of magnitudes has, unfortunately, not been adopted in the above catalogues, but the differences in mags. 1 to 8, according to the various scales in use, are so slight that they may be practically ignored for my present purpose without much disadvantage.

Magnitudes	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-	Totals.
Ashy	...	...	...	...	...	1	5	67	73
Blue	1	2	...	1	...	5	30	242	281
Crimson	...	...	...	...	...	...	...	1	1
Garnet	...	...	...	...	...	...	...	1	1
Green	...	...	...	1	4	2	7	25	39
Grey	...	...	...	...	2	3	2	28	35
Lilac	...	...	...	...	2	4	5	25	36
Orange	3	6	21	47	120	96	65	18	376
Purple	...	...	...	...	1	2	1	20	24
Red	2	2	4	8	40	63	107	194	420
Ruby	...	...	...	...	...	...	...	9	9
Scarlet	...	...	...	...	...	...	2	3	5
Violet	...	...	...	...	...	...	5	9	14
White	6	30	79	158	410	417	487	1041	2628
Yellow	8	22	79	129	265	250	154	135	1042
	20	62	183	344	844	843	870	1818	4984

University College School, W.C.:
    1889, *October* 29.

Conjunction of Mars and Saturn, 1889 *September* 20. *Measurements taken at Arley Cottage, Mount Nugent, Cavan.* By Major S. H. Maxwell.

Lat. 53° 49′ 30″. Long. W. 0^h 29^m 13^s.
Instrument, 6-inch refractor, by Grubb.
Micrometer, bifilar, by Grubb.

No.	G.M.T.	Pos. Ang.	Dist.	Ref.	Dist.	Par.	Cor. Dist.	
	h m s	°	″	″	″	″	″	
1	17 17 4	304·0	222·7	+0·5	223·2	+2·3	225·5	
2	17 19 34	304·5	218·4	,,	218·9	,,	221·2	
3	17 22 9	305·0	214·1	,,	214·6	,,	216·9	
4	17 31 41	305·8	203·5	,,	204·0	,,	206·3	
5	17 35 32	306·0	198·8	,,	199·3	,,	201·6	
6	17 41 51	307·0	191·0	,,	191·5	,,	193·8	
7	17 53 49	308·0	176·9	+0·4	177·3	,,	179·6	
8	17 57 37	309·0	171·0	,,	171·4	,,	173·7	
9	18 4 7	309·5	162·9	,,	163·3	,,	165·6	
10	18 7 56	310·2	157·6	+0·3	157·9	,,	160·2	
11	18 12 39	310·8	153·3	,,	153·6	,,	155·9	
12	18 18 47	312·0	145·4	,,	145·7	,,	148·0	
13	18 31 46	315·5	130·6	+0·2	130·8	,,	133·1	Saturn very faint.
14	18 41 56	318·5	120·0	,,	120·2	,,	122·5	,, barely visible.

Sky became too bright to see any more of either planet.

The measurements were taken on the outside limbs of both planets, and 9″·6 (*Mars*, 2″·3, *Saturn*, 7″·3) subtracted for semi-diameter.

Time was taken by watch compared before and after observations with chronometer, and the error of the latter taken by five sextant altitudes of Sun the same afternoon.

Each number represents a single setting of the position and distance wires, as clouds were so frequent that only occasional measurements were possible.

Observations of Mars and Saturn at their Conjunction, 1889 *September* 19, *made at the Royal Observatory, Greenwich.* By E. W. Maunder.

A careful watch was kept for the two planets from their rising, but it was not until 17ʰ G.M.T. that the clouds passed away from before them sufficiently for any observations to be made. The following differences of Right Ascension and North Polar Distance were then observed by means of the transit micrometer of the south-east equatorial; aperture 12·8 inches. The times of transit of the two planets over the first four of the nine galvanic wires were recorded on the chronograph, and the differences of N.P.D. of the planets measured by the declination micrometer. The observations were made with considerable difficulty, as the images throughout were ill-defined and unsteady, and *Saturn* was pale and faint, the background of the sky being bright throughout the observations. Indeed the Sun had risen before the last six transits were taken.

The centres of both planets were observed in every instance except the second transit, when the first limb of *Saturn* was observed in R.A., but the centre in N.P.D. This observation has been corrected for the semi-diameter of the planet. The observations have been all corrected for the differential effect of parallax and refraction, and in the last two columns they are all reduced to the same epoch, 17ʰ 30ᵐ G.M.T. The last observation has been rejected in taking the mean, as *Saturn* was then so faint that it could only be seen with the greatest difficulty, and was continually lost to sight. No further observations could be made after this transit as *Saturn* was then quite invisible.

<div align="center">Mars.—Saturn.</div>

No. of Obs.	G.M.T. of Observation			Corr. for Par.	Refrac.	Diff. in R.A. Corrected.	Corr. for Par.	Refrac.	Diff. in N.P.D. Corrected.	Reduced to 17ʰ 30ᵐ Diff. in R.A.	Diff. in N.P.D.
	h	m	s	s	s	s	″	′	′ ″	s	′ ″
1	17	9	6	−0·11	−0·04	−13·27	−1·96	−0·2	−2 10·1	−11·55	−2 0·9
2	17	13	3	−0·11	−0·04	−13·04	−1·96	−0.2	−2 7·2	−11·65	−1 59·8
3	17	23	2	−0·11	−0·03	−12·14	−1·94	−0·2	−2 5·4	−11·57	−2 2·3
4	17	27	3	−0·11	−0·03	−11·79	−1·93	−·0·2	−2 2·9	−11·55	−2 1·6
5	17	29	3	−0·11	−0·03	−11·74	−1·93	−0·1	−2 1·0	−11·66	−2 0·6
6	17	31	4	−0·11	−0·03	−11·47	−1·92	−0·1	−1 59·9	−11·56	−2 0·3
7	17	33	6	−0·11	−0·02	−11·33	−1·92	−0·1	−1 58·8	−11·58	−2 0·1
8	17	35	3	−0·11	−0·02	−11·25	−1·92	−0·1	−1 58·0	−11·67	−2 0·3
9	17	37	2	−0·11	−0·02	−11·05	−1·92	−0·1	−1 57·4	−11·63	−2 0·5
10	17	39	3	−0·11	−0·02	−10·91	−1·91	−0·1	−1 57·0	−11·65	−2 1·0
11	17	41	3	−0·11	−0·02	−10·51	−1·91	−0·1	−1 56·6	−11·42	−2 1·4
12	17	43	3	−0·11	−0·02	−10·43	−1·91	−0·1	−1 56·5	−11·50	−2 2·2
13	17	45	1	−0·11	−0·02	−10·38	−1·90	−0·1	−1 55·8	−11·61	−2 2·4
14	17	47	4	−0·11	−0·02	−10·08	−1·90	−0·1	−1 55·1	−11·48	−2 2·6
15	17	51	2	−0·10	−0·02	− 9·85	−1·89	−0·1	−1 52·6	−11·58	−2 1·8
16	17	53	2	−0·10	−0·02	− 9·75	−1·89	−0·1	−1 50·7	−11·64	−2 0·8
17	17	55	2	−0·10	−0·02	− 9·50	−1·89	−0·1	−1 50·0	−11·56	−2 1·0
18	17	57	3	−0·10	−0·02	− 9·25	−1·88	−0·1	−1 47·0	−11·47	−1 58·9
19	17	59	4	−0·10	−0·02	− (9·65)	−1·88	−0·1	− (1 47·6)	−(12·04)	(−2 0·3)
									Mean	−11·574	−2 1·02

A positive eyepiece, power 130, was employed throughout.

Observations of the Occultation of Jupiter by the Moon, made at the Royal Observatory, Greenwich, 1889 August 7.

<div align="center">(Communicated by the Astronomer Royal.)</div>

	Phenomenon.	Telescope.	Power.	Moon's Limb.	Mean Solar Time of Observation.			Observer.
					h	m	s	
(a)	Disapp. First contact	S.E. Eq.	60	Dark	7	4	34·33	W. C.
(b)	,,	E. Eq.	70	,,	7	4	36·19	C.
	,,	Simms' No. 1	75	,,	7	4	28·97	S. D.
(c)	Last contact	S.E. Eq.	60	,,	7	6	5·33	W. C.
(d)	,,	E. Eq.	70	,,	7	6	10·92	C.
	,,	Simms' No. 1	75	,,	7	6	7·97	S. D.
(e)	Reapp. First contact	S. E. Eq.	200	Bright	7	59	56·37	W. C.
(f)	,,	E. Eq.	70	,,	7	59	54·59	C.

	Phenomenon.	Telescope.	Power.	Moon's Limb.	Mean Solar Time of Observation.	Obser- ver.
					h m s	
	First contact	Altaz.	100	Bright	7 59 54·49	J. P.
	,,	Simms' No. 1	75	,,	7 59 52·26	S. D.
(g)	Last contact	S.E. Eq.	200	,,	8 1 39·09	W. C.
(h)	,,	E. Eq.	70	,,	8 1 34·81	C.
	,,	Altaz.	100	,,	8 1 37·70	J. P.
	,,	Simms' No. 1	75	,,	8 · 1 38·76	S. D.
	Reapp. Satellite II.	Lassell Refl.	280	,,	8 6 15·17	H. T.
	,,	E. Eq.	70	,,	8 6 17·03	C.
	,,	Simms' No. 1	75	,,	8 6 18·78	S. D.
	Satellite IV.	Lassell Refl.	280	,,	8 18 57·18	H. T.
	,,	Simms' No. 1	75	,,	8 20 31·85	S. D.

Notes.

(a) *Jupiter* faint and time uncertain to several seconds.
(b) Observation not easy owing to the faintness of *Jupiter*.
(c) Observation satisfactory.
(d) The dark limb of the Moon was very distinct as seen on *Jupiter*. This observation considered better than first contact.
(e) Probably a little late ; *Jupiter* very much fainter than the Moon.
(f) Probably a little late ; reappeared earlier than expected.
(g) Shortly before last contact there appeared to be a narrow dark band forming an outline to the Moon's limb on the much fainter disk of *Jupiter*. At about 8ʰ 1ᵐ 37ˢ this band began to grow darker, and the first black separation between the limbs was seen at the time given for last contact, but only in the middle of the narrow band. Four seconds later the band had become black all over, and began to widen rapidly. The appearances were similar to the description of the black drop in the Transit of *Venus*.
(h) At the reappearance *Jupiter* appeared of a faint livid colour, belts very black. As the distance between the Moon and *Jupiter* increased the western limb gradually recovered its normal colour, which slowly spread over the disk, giving the appearance of emergence from a shadow, the belts gradually becoming of a coppery hue.

The clear aperture of the mirror of the Lassell Reflector is 24 inches, of the object-glass of the south-east equatorial 12·8 inches, of the east equatorial 6·7 inches, of the altazimuth 3¾ inches, of Simms' No. 1 (a detached telescope), 4 inches.

The initials W. C., H. T., C., J. P., and S. D. are those of Mr. Christie, Mr. Turner, Mr. Criswick, Mr. Power, and Mr. Dolman respectively.

Royal Observatory, Greenwich:
    1889 *November* 12.

Occultation of the planet Jupiter and two Satellites by the Moon on August 7, 1889; observed at the Radcliffe Observatory, Oxford. By E. J. Stone, Esq., M.A., F.R.S., Radcliffe Observer.

The heliometer and 7-inch telescope were unavailable for the observation of the disappearance, from the obstruction of the view by trees and buildings. The reappearance, from the same cause, could not be observed with the heliometer.

I watched for the reappearance of *Jupiter* with the 7-inch instrument, power 125, but the first appearance was lost from passing cloud. The sky gradually cleared and I was able to see the rest of the phenomena without any interference from cloud. I saw nothing of the nature of distortion or shadow, although, as I had no clock or chronometer, my attention was particularly directed to these points.

The contrast of brightness between *Jupiter* and the Moon was very striking.

Owing to passing cloud the first contact at reappearance was not seen by the three observers stationed near the main building, but it was apparently well observed with the Barclay Equatorial, about 100 yards west.

The following are the times of contacts and remarks, given by the other observers:—

The planet Jupiter.

Disappearance, at Moon's dark limb.

			Local Sidereal Time.	G.M.T. of Observation.	Observer.
			h m s	h m s	
First contact	...	...	16 4 33·7	7 3 39·0	W.
,,	...	...	16 4 35·2	7 3 (40·5)	R.
,,	...	...	16 4 39·7	7 3 (45·0)	F. B.
♃ dichotomised	...	...	16 5 8·7	7 4 14·0	W.
,,	...	...	16 5 15·2	7 4 20·4	R.
Last appearance	...	...	16 6 8·7	7 5 13·8	W.
,,	...	...	16 6 8·5	7 5 13·6	R.
,,	...	...	16 6 8·2	7 5 13·3	F. B.

Reappearance, at Moon's bright limb.

First contact	...	...	16 59 5·1	7 58 1·5	R.
♃ projecting, say ⅙ of diameter			16 59 30·7	7 58 27·1	W.
Dichotomised	...	...	16 59 46·7	7 58 43·0	W.
,,	...	...	16 59 55·1	7 58 51·4	R.
Last contact	...	...	17 0 56·7	7 59 52·8	W.
,,	...	...	17 0 51·6	7 59 47·7	R.

Jupiter's Satellites.

Reappearance, at Moon's bright limb.

			Local Sidereal Time.	G.M.T. of Observation.	Observer.
			h m s	h m s	
Satellite II.	First seen	...	17 5 26·6	8 4 22·0	R.
„	„	...	17 5 40·7	8 4 36·1	W.
Satellite IV.	First seen	...	17 (19) 10·1	8 18 3·3	R.
„	„	...	17 19 31·7	8 18 24·8	W.

Clouds were frequently passing.

Observers' Remarks.

Mr. W. Wickham.   Marlborough Telescope: aperture, $3\frac{1}{4}$-inch; power, 80.

Disappearance of *Jupiter.*

At $1\frac{1}{2}^m$ before first contact a shadow, like a crape veil, on the disc of *Jupiter* was noticed darkening that part of the planet nearest the Moon (similar to the "Earth-shine" on the new Moon), but extending over roughly $\frac{1}{6}$ of *Jupiter's* disc from the first limb.

The time of "last appearance" considered very good, a tiny speck of light being last seen of the limb.

Reappearance of *Jupiter.*

First contact.   Just lost in cloud, which after passing showed part of *Jupiter* projecting (say $\frac{1}{6}$ of its diameter).

Last contact.   Good; sharp tangent, no black drop; the time noted is when a line of discontinuity was just shown between *Jupiter* and the Moon's limb.

The shadow noted at Disappearance was also seen at Reappearance on the following side of *Jupiter*, after the planet was quite free from the Moon, for about 2^m of time from last contact, it then ($8^h 2^m \pm$ G.M.T.) gradually paled, but was still visible for another 2^m or 3^m.

Reappearance of Satellite IV.

Very faint, may be 1ˢ in error.

Mr. W. H. Robinson. Barclay Equatorial : aperture, 10-inch ; power, 100.

Disappearance of Jupiter.

About 1ᵐ before the first contact of *Jupiter* with the dark limb of the Moon I observed a change in the appearance of *Jupiter*, one quarter of the disc of the planet nearest the Moon's advancing limb being ill-defined and shaded, while the remaining ¾ of disc was sharply defined.

After watching this interference phenomenon for several seconds, I looked away in order to ascertain if it were caused by cloud, and, concluding that it was not, I resumed my observation at the telescope, when I found that I had just missed the first contact, the Moon's sharp edge having distinctly cut into *Jupiter*, thus :—

When the Moon's dark limb was well on *Jupiter* there appeared to be a bright line on *Jupiter* immediately contiguous to the Moon's limb.

Last contact. Good, almost instantaneous.

Reappearance of Jupiter.

First contact. Observation considered good. Well seen. The merest trace of *Jupiter's* limb visible. Very pale in comparison with Moon's bright limb.

As the Moon receded, an unmistakable shade (about ¼ of *Jupiter's* diameter) was seen projected on Jupiter, thus :—

This shaded band was parallel to the Moon's limb, and was visible during the whole of the transit of the Moon's limb over *Jupiter.*

Last contact.   Half a second *before* the time given, *Jupiter* was " hanging on " the Moon.

Half a second *after* "last contact" *Jupiter* just free from Moon's limb.

Reappearance of *Jupiter's* Satellites.

Good observations.

Mr. F. A. Bellamy.   Dollond Telescope: aperture, 3¾-inch ; power, 80.

Disappearance of *Jupiter.*

First contact.   Bad definition, no sharp edge ; may be quite 5ˢ late.

Last contact.   Good observation.   Limb very sharp.   Quite satisfactory.

Radcliffe Observatory, Oxford:
1889, *November* 7.

Occultation of Jupiter by the Moon, 1889 *August* 7, *observed at Forest Lodge, Maresfield.*   By Captain William Noble.

As the Sun was still above the horizon when the occultation began, and lighted a cirrous haze drifting over the Moon and *Jupiter*, the observation of disappearance was extremely difficult. The planet looked like the veriest ghost of itself, and had to be very steadily regarded for a defined limb to be seen at all.   The actual observation of first contact was simply impossible ; but by 16ʰ 11ᵐ 1ˢ L.S.T. the Moon's limb had perceptibly encroached on *Jupiter*, who finally disappeared at 16ʰ 12ᵐ 32ˢ·6 L.S.T. =7ʰ 6ᵐ 34ˢ·9 L.M.T., or 7ʰ 16ᵐ 17ˢ·8 G.M.T.   The interest of the occultation, however, culminated in the reappearance of the planet ; the first glimpse of which I caught at 17ʰ 5ᵐ 52ˢ·4 L.S.T., perhaps one or two seconds late.   It had finally emerged, and, as nearly as I could judge, its limb and that of the Moon were tangent at 17ʰ 7ᵐ 45ˢ·4 L.S.T.=8ʰ 1ᵐ 38ˢ·68 L.M.T., or

$8^h\ 1^m\ 21^s\cdot57$ G.M.T. As the planet appeared to emerge from behind the Moon the two equatorial belts were notably hard, dark, and sharp, and one towards *Jupiter's* south pole was also conspicuous. The most remarkable feature visible, though, I have endeavoured to depict in the accompanying sketch. It was a strongly marked shading, following the outline of the Moon's limb; and it gave a perfectly stereoscopic effect to the Moon and planet, the former being apparently much nearer to the eye. The detail on the planet's surface seemed generally to improve from its proximity to the Moon's limb, and presented that sharpness often incident on the passage of a light cloud or haze over the planet. *Jupiter* looked, generally, somewhat darker than the Moon, but this seemed rather an effect of colouring

than of obscuration. The shadow, of which the sketch gives a very fair idea, was, though, as I have previously said, by far the most remarkable feature observable. I employed a power of 135 (of course with a positive eye-piece) on the position micrometer of my 4·2 inch equatorial. The latitude of my Observatory is $51^\circ\ 0'\ 59''\cdot8$ north, and its longitude $17\cdot11$ seconds east of Greenwich.

The Late Occultation of Jupiter. By the Rev. S. J. Johnson, M.A.

The sky was everything that could be desired here on the evening of August 7 for the occultation of *Jupiter*. A higher power than 50 on 3¼-inch was not advisable. Contrary to what I had expected, the relative brightness of the planet seemed slightly fainter than that of the Moon on eye estimation. As the dark limb of the Moon was invisible, the impression produced on the eye of the observer, in an irresistible manner, was that of a rapid eclipse of a miniature Sun or Moon. At $7^h\ 0^m\ 24^s$ (time by sextant) there appeared an indentation on the circle of *Jupiter*. This was probably three or four seconds late. At $7^h\ 1^m\ 58^s$ the whole was submerged behind the dark limb of the Moon. First impression of the reappearance of *Jupiter* at $7^h\ 52^m\ 34^s$. Planet entirely clear of the Moon $7^h\ 54^m\ 20^s$. The Sun had set less than twenty minutes. The striking spectacle of all was the pale white-yellow colour of *Jupiter* close to the

bright golden disc of the Moon, when the planet was half out, and, in addition to this, the distinctness of the principal belts.

[The planet was not discernible in a good opera glass previous to immersion, but on the occasion of the last occultation in broad daylight, May 24, 1860, at $4\frac{1}{2}^{\text{h}}$, the disappearance could be seen without difficulty by means of an old ship glass, power 16, sheltered from the Sun's rays.]

Vicarage, Melplash, Dorset :
August 9.

Orbit of Comet III. of 1888.   By Lieut.-Gen. J. F. Tennant,
R.E., F.R.S.

This comet was discovered by Mr. Brooks on August 7, when it had already passed its perihelion seven days. The first accurate observation of it I have found is at Carleton College on the following day, but it is alone, and therefore I have not used it in my work, as it promised to complicate the deduction of the normal places. The comet was extensively observed till September 12, after which date the observations are fewer, and after October 10 I have only observations at Paris on two days, which I owe to the courtesy of Admiral Mouchez, Director of the Observatory, who sent me all the observations there in MS. I am also indebted to Mr. Plummer, of Orwell Park Observatory, for MS. observations, since published in the *Monthly Notices*.

I have examined all observations I could find in the *Astronomische Nachrichten*, Gould's *Journal, Monthly Notices, Comptes Rendus, Bulletin Astronomique,* and *Sidereal Messenger*. I have generally omitted to use all which depended on *Durchmusterung* stars; those of October 24 at Paris, however, are an exception, for I was unwilling to trust entirely to the observation of October 27 for a last normal place, though it would have agreed better with my final orbit than that I actually deduced.*

From the observations at Strassburg on August 10, at Kiel on September 1, and Dresden on September 23, I deduced a parabolic orbit.

$$T = \text{July } 31 \cdot 109783 \text{ G.M.T.}$$

$$\log q = 9 \cdot 9551934$$

$$
\begin{aligned}
\Omega &= 101 \ 29 \ 45 \cdot 0 \\
\varpi &= 160 \ 39 \ 05 \cdot 1 \\
i &= \ 74 \ 11 \ 37 \cdot 5
\end{aligned}
\left.\right\}
\begin{array}{l}\text{Ecliptic and}\\ \text{equinox of}\\ 1888 \cdot 0.\end{array}
\qquad
\begin{aligned}
\Omega' &= \ 94 \ 05 \ 42 \cdot 38 \\
\varpi' &= 177 \ 37 \ 07 \cdot 00 \\
i' &= \ 70 \ 57 \ 41 \cdot 32
\end{aligned}
\left.\right\}
\begin{array}{l}\text{Equator and}\\ \text{equinox of}\\ 1888 \cdot 0.\end{array}
$$

By comparing an orbit almost identical † with this with the

---

* The observations at Padua on August 12, and at Brussels on August 27, seem to be erroneously printed, and have been rejected.

† The difference arose from an error in copying a figure, and was very slight.

observations, and combining them, first into daily groups and
then into groups of several days, I obtained, using only first
powers of the time intervals in solving the equations of condition,
the following eight normal places, to which were assigned
weights nearly proportional to the number of observations used
for them.   That is, to Nos. 1, 2, and 3 each 2, to Nos. 4 and 5
each 1·5, to Nos. 6 and 7 each 1, and to No. 8 0·15.

No.	Observations.	No.	Date.	True α.	True δ.
1	Aug. 9–12	36	Aug. 10·5	157 37 37·0	+44 50 45·1
2	13–24	34	17·5	171 16 42·0	43 57 38·9
	25–31	34	28·5	191 55 49·2	39 08 06·6
4	Sept. 1–6	24	Sept. 4·5	203 19 24·2	34 23 28·3
5	7–17	20	12·5	214 19 08·7	28 13 18·1
6	23–30	14	26·5	229 11 32·8	17·33 25·0
7	Oct. 1–10	15	Oct. 5·5	236 38 59·5	11 34 55·6
8	24–27	2	25·5	249 42 53·1	1 22 57·4

Equations of condition having been formed for each observa-
tion, normal equations were formed and solved in the usual way,
giving the following corrections to the elements :—

$$\delta\,T = -0·014614 \ \pm 0·014811$$
$$\delta \log q = -0·0001320 \pm 0·0000903$$
$$\delta\, e = -0·0021225 \pm 0·0007193$$
$$\delta\,\Omega' = +43·57 \qquad \pm 13·04$$
$$\delta\,\pi' = - \ 4·95 \qquad \pm 68·24$$
$$\delta\,i' = +30·77 \qquad \pm 11·66$$

The separation of $\delta\,T$ and $\delta\,\pi'$ in the elimination is very un-
certain, and the probable errors of the elements mainly arise
from the uncertainty of T which was left to the last.

The probable error of $\delta\,e$ is about one-third of its amount,
whence it would appear that the orbit is really elliptic, though
the eccentricity is very uncertain.   Had the comet been dis-
covered a few days sooner, and observed about perihelion, we
might have had doubts removed.

The resulting elements are :—

Perihelion passage, July 31, ·095169; July 31, 2ʰ 17ᵐ 02ˢ·6.

$$\log q = 9·9550614$$
$$e = 0·9978775$$

$$\Omega' = 94 \ 06 \ 25·95$$
$$\pi' = 177 \ 37 \ 02·05$$ Equinox and equator of 1888·0.
$$i' = 70 \ 58 \ 12·09$$

Computing from these elements the places at the times of

the normals, we have the following values of observation-computation.

δ R.A.	$+2''3$	$-2''3$	$-1''8$	$-0''8$	$-3''1$	$+4''8$	$+3''8$	$-15''8$
Dec.	$+3·6$	$-0·3$	$-3·9$	$-0·4$	$+1·9$	$+2·6$	$+3·4$	$+5·4$

The probable error of one of the constants of the equations of condition of the weight 1 is found $3''·18$, and on the whole the observations seem satisfactorily represented.

The ecliptic elements are finally : —

$$T = \text{July } 31·0952 = \text{July } 31\ 2\ 17 \quad \overset{d\ h\ m}{}$$

$$\Omega = 101\ 30\ 11$$

$$\pi = 160\ 38\ 50$$

$$i = 74\ 12\ 23$$

$$\log q = 9·9550614$$

$$e = 0·9979$$

Brooks's Comet.   By J. I. Plummer, M.A.

Some recent observations which I have made of the two portions of Brooks's Comet seem to point to even greater interest than the actual division of the comet may have caused. The only fragment of the main body which I have been able to see at Orwell Park is the intermediate one of the three illustrated in the *Astronomische Nachrichten*, No. 2922, from the Vienna observations. During the month of September I succeeded in making eight sets of comparisons between the main body and this fragment which show a gradual increase in the distance both in R.A. and declination, but the rate of movement of separation was distinctly slower than in the previous month. Later I succeeded in making four similar sets of comparisons between October 17 and October 24, at which times I found that the fragment had greatly diminished in lustre relatively to the main comet, and also that the differences of R.A. and declination had certainly lessened, indicating an actual motion of approach. I should be very glad to have this fact verified by other observers, and as it appears probable that after the present bright moonlight the light will be still less, I would suggest that the matter is of sufficient interest to induce the possessors of large telescopes to pay attention to this comet without delay. I would add that it would appear that the period at which the greatest divergence took place is that of perihelion passage, i.e. September 26. The observations to which I have referred will be published in due course.

1889, *November* 8.

Observations of Comet e 1889 (Davidson), made at the Melbourne Observatory with the South Equatorial and Dark-field Micrometer. Observer: P. Baracchi.

(Communicated by R. L. J. Ellery, F.R.S., Government Astronomer.)

Date.	Melbourne Mean Time.	Comet −Star Δα	ΔN.P.D.	No. of Meas.	Comet Apparent α	Log (p×Δ)	Comet Apparent N.P.D.	Log (p×Δ)	Red. to App. Place.	Star α 1889·0	Star N.P.D. 1889·0
	h m s	m s	′ ″		h m s		° ′ ″		s	h m s	° ′ ″
1889 July 23	8 54 43·2	+5 23·88	−15 4·0	3	12 46 10·98	+9·9698	122 27 35·7	+0·467	+11·2	12 40 46·73	122 42 28·48 (a)
25	9 53 16·7	−3 15·39	− 2 27·9	1	13 11 9·06	+9·9704	116 47 15·0	+0·603	+ 9·0	13 14 23·87	116 49 33·9 (b)
26	11 30 36·0	+8 6·10	− 8 58·8	2	13 23 8·26	+9·9708	113 44 25·9	+0·726	+ 8·0	13 15 1·65	113 53 16·7 (c)
29	9 33 51·8	+2 38·93	− 4 19·9	5	13 52 15·94	+9·9637	105 31 36·7	+0·645	+ 4·5	13 49 36·30	105 35 52·1 (d)
29	9 52 49·6	−6 49·39	−18 48·2	1	13 52 22·56	+9·9654	105 29 30·2	+0·659	+ 4·3	13 59 11·18	105 48 14·1 (e)
30	7 21 31·6	−13 13·74	− 6 47·4	3	14 0 19·23	+9·9363	103 5 6·7	+0·595	+ 3·2	14 13 32·13	103 11 50·9 (f)
Aug. 1	9 53 18·1	+1 7·19	+ 9 40·1	7	14 17 18·08	+9·9631	97 44 39·8	+0·700	+ 1·0	14 16 10·08	97 34 58·7 (g)
2	9 16 26·1	+2 51·66	−10 13·7	5	14 24 27·24	+9·9584	95 26 56·7	+0·704	+ 0·2	14 21 34·77	95 37 10·2 (h)
2	10 9 48·9	−0 30·23	+ 3 25·1	7	14 24 43·35	+9·9640	95 21 56·3	+0·716	0·0	14 25 12·75	95 18 31·2 (i)
18	6 59 46·9	+0 41·29	+ 2 17·7	10	15 40 21·69	+9·9155	72 25 16·4	+0·861	− 9·7	15 39 39·52	72 23 8·4 (j)

Authorities.—(a) Stone 7058. (b) ½ (Yarnall 5515 + 2 Gould $\frac{xiii}{528}$). (c) Stone 7314. (d) ½ (Lal. 25596 + 3 [O. A. 13247]).
(e) Yarnall 5816. (f) Yarnall 5911. (g) Armagh 1668. (h) ½ (Gr. 7 year Cat. 1864 + Grant 3577). (i) Yarnall 5990. (j) 26 Serpentis.
Melbourne Transit Circle.

Remarks.

July 23.—☿ a bright object. Sharp stellar nucleus 5th or 6th mag. Tail south following more than 30′ long. Diameter at head 4′ or 5′. Easily visible to the naked eye. Bisections of the nucleus easy.

July 25.—Only one measure taken through a short break in the clouds. Same appearance as on July 23.

July 26.—Overcast in early evening. ☿ low, observed through thick haze. Bisections difficult.

July 29.—Clouds interfering. ☿ observed through occasional breaks. Bisections easy.

July 30.—Nucleus diffused. Bad definition. Bisections unsatisfactory. Comet a little fainter. Nucleus no brighter than 6th mag. Tail south following about 30′ long. Still easily visible to the naked eye.

August 1.—Same appearance as on July 30. Bisections easy.

August 2.—Same appearance. Good bisections. Still visible to the naked eye.

August 18.—☿ much fainter. Nucleus quite diffused. Elongated nebulosity south following, about 20′ long. Bisections satisfactory.

Parabolic Elements Computed from Observations of July 23, 26, and 29.

$$T\ 1889,\ July\ 19\cdot28958\ G.M.T.$$

$$
\left.
\begin{array}{l}
\omega\ \ 14°\ \ 7′\ \ 33″ \\
\Omega\ 286\ \ \ 8\ \ \ 17 \\
i\ \ \ 66\ \ \ 1\ \ \ 53
\end{array}
\right\} M.E.\ 1889\cdot0
$$

$$\log q\ \ 0\cdot016927$$

$$(O-C) \begin{cases} \cos\beta\ \Delta\lambda = -1″\cdot3 \\ \Delta\beta = +2″\cdot0 \end{cases}$$

Observations of Comet e 1889 (Davidson), made at Sydney Observatory with the 11½-inch Equatorial and Filar Micrometer.

(Communicated by H. C. Russell, B.A., F.R.S., Government Astronomer.)

Date. 1889.	Sydney M.T. h m s	Star.	No. of Comp.	Comet—Star ΔR.A. m s	ΔN.P.D.	Comet's Apparent R.A. h m s	N.P.D. ° ' "	Log. ρΔ for R.A.	for N.P.D.	Obs.
July 22	8 51 47	1	4	−4 30·86	−15 36·87	12 32 43·30	125 8 42·31	9·736	0·348	R.
22	10 37 55	2	2	+2 45·95	+ 8 1·57	12 33 42·10	124 57 18·29	9·777	0·616	Pk.
23	7 27 43	3	15	+4 23·73	− 2 26·76	12 45 10·87	122 40 12·22	9·590	0·069	R.
23	8 58 16	4	10	+1 17·32	−53 48·25	12 45 57·67	122 30 0·22	9·730	0·386	R.
24	7 40 0	5	12	+2 9·50	−19 35 17	12 57 54·91	119 54 39·56	9·585	0·192	R.
24	8 58 25	6	9	+1 49·44	+ 0 52·91	12 58 34·18	119 45 32·22	9·699	0·408	R.
24	8 58 25	7	9	−2 59·90	− 5 8·24	12 58 34·31	119 45 28·80	9·699	0·408	R.
26	9 0 33	8	1	+4 42·00	− 3 55·62	12 21 49·29	114 5 25·74	9·663	0·467	R,
26	9 0 33	9	1	+4 32·80	+ 0 46·87	13 21 49·40	114 5 25·88	9·663	0·467	R.
26	10 11 10	9	2	+5 4·24	− 7 43·17	13 22 20·84	113 56 55·84	9·718	0·578	R.
29	7 19 13	10	5	−3 34·32	+ 2 41·02	...	...	9·396	0·472	Pk.
29	7 19 13	11	5	−7 56·66	+ 1 38·28	13 51 15·27	105 49 57·22	9·396	0·472	Pk.
29	9 48 29	12	6	−9 0·19	− 6 55·61	13 52 11·86	105 32 47·54	9·669	0·595	R.
29	9 53 37	13	5	−6 54·00	+ 2 42·98	13 52 13·96	105 32 14·45	9·673	0·599	R.

The observers were R.=Russell; Pk.=Pollock. The reductions have been made by Mr. Pollock.

Mean Places for 1890·0 of Comparison Stars.

Star.	R.A.	Red. to App. Place.	N.P.D.	Red. to App. Place.	Authority.
	h m s	s	o ′ ″	″	
1	12 37 13·81	+0·35	125 24 7·02	+12·16	Argentine Gen. Cat. 17317.
2	12 30 55·84	+0·31	124 49 4·76	+11·96	Argentine Gen. Cat. 17162.
3	12 40 46·77	+0·37	122 42 27·74	+11·24	Stone 7058, Argent. Gen. Cat. 17403.
4	12 44 39·95	+0·40	123 23 37·01	+11·46	Stone 7084, Argent. Gen. Cat. 17473.
5	12 55 44·95	+0·46	120 14 4·38	+10·35	Stone 7174, Argent. Gen. Cat. 17725.
6	12 56 44·26	+0·48	119 44 29·11	+10·20	Argent. Gen. Cat. 17738.
7	13 1 33·71	+0·50	119 50 26·84	+10·20	Stone 7218, Argent. Gen. Cat. 17855.
8	13 17 6·71	+0·58	114 9 13·17	+ 8·19	Argent. Gen. Cat. 18215.
9	13 17 16·02	+0·58	114 4 31·00	+ 8·01	Argent. Gen. Cat. 18221.
10	...	...	...	...	Lalande 25716.
11	13 59 11·15	+0·78	105 48 14·54	+ 4·40	1st Radcliffe Cat. 3128, Yarnall 5816, 2nd Radcliffe Cat. 1349.
12	14 1 11·26	+0·79	105 39 38·83	+ 4·32	2nd Radcliffe Cnt. 1357, Greenwich 7-year Cat. for 1860 1129, Yarnall 5832
13	13 59 7·18	+0·78	105 29 27·18	+ 4·29	Weisse's Bessel xiii. 1001.

Ephemerides of the Satellites of Saturn, 1889–90. By A. Marth. (Concluded.)

Approximate Differences of Right Ascension and Declination between the three outer Satellites and the centre of Saturn.

Greenwich Noon. 1890.	Titan.		Hyperion.		Iapetus.	
	$a_a - A$	$\delta_a - D$	$a_7 - A$	$\delta_7 - D$	$a_8 - A$	$\delta_8 - D$
Jan. 1	+ 10·27	+ 31·0	− 1·91	+ 29·9	− 38·29	+ 31·7
2	+ 6·28	+ 32·8	− 6·64	+ 21·8	38·39	33·4
3	+ 1·23	+ 29·2	− 10·83	+ 11·9	38·24	34·8
4	− 4·04	+ 20·8	− 14·23	+ 1·0	37·84	36·1
5	− 8·69	+ 9·2	− 16·66	− 10·0	37·19	37·0
6	− 12·04	− 4·0	− 18·02	− 20·5	− 36·30	+ 37·7
7	− 13·62	− 16·7	− 18·27	− 29·8	35·18	38·2
8	− 13·25	− 27·0	− 17·42	− 37·4	33·83	38·3
9	− 10·99	− 33·6	− 15·51	− 42·7	32·26	38·2
10	− 7·07	− 35·5	− 12·64	− 45·5	30 48	37 9
11	− 2·31	− 32·4	− 8·93	− 45·3	− 28·50	+ 37·3
12	+ 2·90	− 24·5	− 4·59	− 42·0	26·34	36·4
13	+ 7·68	− 12·9	+ 0·11	− 35·5	24·01	35·3
14	+ 11·28	+ 0·8	+ 4·81	− 25·9	21·53	34·0
15	+ 13·06	+ 14·4	+ 9·05	− 13·7	18·91	32·5
16	+ 12·71	+ 25·8	+ 12·30	0·0	− 16·16	+ 30·7
17	+ 10 22	+ 32·9	+ 14·08	+ 13·7	13·30	28·7
18	+ 6 01	+ 34·6	+ 14·05	+ 25·8	10 36	26·6
19	+ 0·79	+ 30 6	+ 12·15	+ 34·6	7·35	24·3
·20	− 4·58	+ 21·6	+ 8·68	+ 39·0	4·28	21·9
21	− 9·24	+ 9·2	+ 4·14	+ 38·8	− 1 18	+ 19 4
22	− 12·51	− 4·8	− 0·86	+ 34·3	+ 1·94	+ 16·7
23	− 13·95	− 18·1	− 5·81	+ 26·5	5·05	13·9
24	− 13·38	− 29·0	− 10·27	+ 16·4	8·13	11·1
25	− 10 90	− 35·8	− 13·96	+ 4·9	11·18	8·3
26	− 6·87	− 37 6	− 16·67	− 7·0	14·17	5·4
27	− 1·84	− 34·1	− 18·29	− 18·6	+ 17·08	+ 2·5
28	+ 3·45	− 25·6	− 18 78	− 29·1	19·89	− 0·3
29	+ 8·24	− 13·1	− 18·13	− 37·9	22·59	3·1
30	+ 11·74	+ 1·4	− 16·38	− 44·5	25·16	5·9
31	+ 13·35	+ 15·9	− 13·61	− 48·5	27·58	8·6

		Titan.		Hyperion.		Iapetus.	
Greenwich Noon. 1890.		$a_s - A$	$\delta_s - D$	$a_7 - A$	$\delta_7 - D$	$a_s - A$	$\delta_s - D$
Feb.	1	+ 12·78	+ 27·8	− 9·96	− 49·3	+ 29·85	− 11·2
	2	+ 10·03	+ 35·1	− 5·62	− 46·8	31·94	13 7
	3	+ 5·61	+ 36·7	− 0·85	− 40·7	33·83	16·1
	4	+ 0·25	+ 32·1	+ 3·99	− 31·3	35·52	18·3
	5	− 5·17	+ 22·4	+ 8·44	− 18·8	37·01	20·3
	6	− 9·78	+ 9·1	+ 12·00	− 4·3	+ 38·27	− 22·2
	7	− 12·92	− 5·7	+ 14·14	+ 10·8	39 29	23·9
	8	− 14·15	− 19·8	+ 14·47	+ 24·6	40·07	25·4
	9	− 13·35	− 31·1	+ 12 89	+ 35·2	40·60	26·7
	10	− 10·65	− 38·1	+ 9·62	+ 41·4	40·88	27·8
	11	− 6·43	− 39·7	+ 5·16	+ 42·6	+ 40·91	− 28·6
	12	− 1·29	− 35·8	+ 0 10	+ 39·0	40·67	29·2
	13	+ 4·04	− 26·5	− 4·97	+ 31·5	40·18	29·7
	14	+ 8·76	− 13·2	− 9·63	+ 21·2	39·43	29 9
	15	+ 12·15	+ 2 2	− 13·52	+ 9·2	38·42	29·8
	16	+ 13·51	+ 17·4	− 16·45	− 3·6	+ 37·16	− 29·5
	17	+ 12·66	+ 29·8	− 18·29	− 16 2	35·66	29·0
	18	+ 9·70	+ 37·3	− 18·98	− 27·9	33·92	28·3
	19	+ 5·11	+ 38·6	− 18·52	− 38·0	31·96	27·4
	20	− 0·34	+ 33·5	− 16·93	− 45·9	29·78	26·3
	21	− 5·74	+ 23·0	− 14·30	− 50·9	+ 27·41	− 25·0
	22	− 10·24	+ 8·8	− 10·75	− 52·9	24·86	23·5
	23	− 13·20	− 6·8	− 6·49	− 51·2	22·14	21·9
	24	− 14·21	− 21·5	− 1·74	− 45·8	19·26	20·1
	25	− 13·17	− 33·2	+ 3·14	− 36·6	16·25	18·2
	26	− 10·27	− 40 3	+ 7·72	− 24·0	+ 13·13	− 16·2
	27	− 5·91	− 41·7	+ 11·49	− 8 9	9·92	14·1
	28	− 0·70	− 37·1	+ 13·92	+ 7·2	6·64	11·9
Mar.	1	+ 4·61	− 27·1	+ 14·60	+ 22·5	+ 3·32	− 9·6
	2	+ 9·21	− 13·0	+ 13·35	+ 35·0	− 0·03	− 7·4
	3	+ 12·36	+ 3·2	+ 10 34	+ 42·9	3·37	5·1
	4	+ 13·51	+ 19·0	+ 6·04	+ 45·5	6·68	2·8
	5	+ 12·43	+ 31·7	+ 1·05	+ 43·0	9·94	− 0·5
	6	+ 9·26	+ 39·1	− 4 06	+ 36·1	13·13	+ 1·7
	7	+ 4·54	+ 40·0	− 8·80	+ 25·9	16·23	3·9
	8	− 0·93	+ 34·4	− 12·84	+ 13 5	− 19 21	+ 6·0
	9	− 6·24	+ 23·1	− 15 94	+ 0·1	22·04	8·0
	10	− 10·58	+ 8 3	− 17·96	− 13·3	24·72	9·9

	Titan.		Hyperion.		Iapetus.	
Greenwich Noon. 1890.	a_6-A	δ_6-D	a_7-A	δ_7-D	a_8-A	δ_8-D
Mar. 11	− 13·29	− 7·9	− 18·84	− 26·0	27·22	11·7
12	− 14·10	− 23·0	− 18·56	− 37·1	29·52	13·3
13	− 12·85	− 34·9	− 17·17	− 46·0	− 31·62	+ 14·8
14	− 9·79	− 41·9	− 14·73	− 52·2	33·49	16·1
15	− 5·34,	− 42·9	− 11 36	− 55·1	35·12	17·3
16	− 0·13	− 37·8	− 7·23	− 54·2	36·51	18·3
17	+ 5·09	− 27·2	− 2·62	− 49·7	37·64	19·2
18	+ 9·52	− 12·4	+ 2·21	− 41·0	− 38·51	+ 19·9
19	+ 12·45	+ 4·3	+ 6·81	− 28·7	39·12	20·4
20	+ 13·36	+ 20·4	+ 10·72	− 13·5	39·46	20·7
21	+ 12·06	+ 33·1	+ 13·41	+ 3·2	39·54	20·9
22	+ 8·75	+ 40·3	+ 14·42	+ 19·5	39·35	20·9
23	+ 3·97	+ 40·8	+ 13·54	+ 33·3	− 38·90	+ 20·7
24	− 1·45	+ 34·6	+ 10·88	+ 42·7	38·19	20·4
25	− 6·63	+ 22·8	+ 6·85	+ 46·8	37·24	19·9
26	− 10·77	+ 7·4	+ 2·03	+ 45·5	36·05	19·3
27	− 13·35	− 9·1	− 3·04	+ 39·4	34·62	18 5
28	− 13·86	− 24·2	− 7·76	+ 29·7	− 32·97	+ 17·6
29	− 12·43	− 36·0	− 11·87	+ 17·5	31·12	16·6
30	− 9·26	− 42·7	− 15·11	+ 4·0	29·08	15·5
31	− 4·78	− 43·3	− 17·29	− 9·8	26·87	14·3
Apr. 1	+ 0·37	− 37·7	− 18·36	− 23·0	24·49	13·0
2	+ 5·45	− 26·6	− 18·31	− 34·8	− 21·96	+ 11·7
3	+ 9·68	− 11·5	− 17·16	− 44·5	19·31	10·3
4	+ 12·39	+ 5·4	− 14·97	− 51·5	16·55	8·8
5	+ 13 09	+ 21·4	− 11·86	− 55·3	13 69	7·3
6	+ 11·63	+ 33·8	− 7·98	− 55·5	10·77	5·8
7	+ 8·22	+ 40·7	− 3·55	− 51·7	− 7·79	+ 4·3
8	+ 3·46	+ 40·7	+ 1·14	− 43 9	4·77	2·8
9	− 1·87	+ 34·0	+ 5·71	− 32·4	− 1·73	+ 1·2
10	− 6·88	+ 21·9	+ 9·69	− 17·7	+ 1·31	− 0·3
11	− 10·82	+ 6·4	+ 12·60	− 1·1	4·33	1 8
12	− 13·12	− 10·0	+ 13·96	+ 15·5	+ 7·32	− 3·3
13	− 13·50	− 25·0	+ 13·51	+ 30·2	10·25	4·7
14	− 11·96	− 36·4	+ 11·29	+ 40·8	13·11	6·0
15	− 8·74	− 42·7	+ 7·63	+ 46·2	15·89	7·3
16	− 4·29	− 42·9	+ 3·08	+ 46·2	18·56	8·6
17	+ 0·69	− 36·9	− 1·80	+ 41·2	+ 20·12	− 9·8

Greenwich Noon. 1890.	Titan.		Hyperion.		Iapetus.	
	$\alpha_6 - A$	$\delta_6 - D$	$\alpha_7 - A$	$\delta_7 - D$	$\alpha_8 - A$	$\delta_8 - D$
Apr. 18	+ 5·67	− 25·6	− 6·51	+ 32·3	23·54	10·9
19	+ 9·71	− 10·4	− 10·64	+ 20·8	25·81	11·9
20	+ 12·21	+ 6·3	− 13·97	+ 7·7	27·93	12·9
21	+ 12·73	+ 22·0	− 16·33	− 5·9	29·88	13·7
22	+ 11·16	+ 34·0	− 17·62	− 18·9	+ 31·65	− 14·5
23	+ 7·73	+ 40·2	− 17·84	− 31·1	33·23	15·2
24	+ 3·03	+ 39·8	− 16·98	− 41·2	34·60	15·8
25	− 2·16	+ 32·9	− 15·11	− 48·8	35·76	16·3
26	− 6·99	+ 20·7	− 12·31	− 53·4	36·71	16·6
27	− 10·73	+ 5·4	− 8·73	− 54·5	+ 37·44	− 16·9
28	− 12·85	− 10·7	− 4·57	− 51·8	37·94	17·1
29	− 13·08	− 25·2	− 0·07	− 45·2	38·22	17·2
30	− 11·49	− 36·1	+ 4·40	− 34·8	38·26	17·2
May 1	− 8·27	− 41·8	+ 8·44	− 21·2	38·07	17·1
2	− 3·89	− 41·6	+ 11·55	− 5·4	+ 37·65	− 16·9
3	+ 1·02	− 35·5	+ 13·28	+ 11·0	37·01	16·6
4	+ 5·77	− 24·2	+ 13·31	+ 25·8	36·14	16·3
5	+ 9·62	− 9·2	+ 11·59	+ 37·2	35·05	15·8
6	+ 11·95	+ 7·0	+ 8·39	+ 43·8	33·75	15·3
7	+ 12·35	+ 22·1	+ 4·19	+ 45·1	+ 32·25	− 14·6
8	+ 10·72	+ 33·4	− 0·46	+ 41·5	30·55	13·9
9	+ 7·31	+ 39·1	− 5·05	+ 33·8	28·66	13·1
10	+ 2·70	+ 38·3	− 9·20	+ 23·3	26·60	12·3
11	− 2·34	+ 31·2	− 12·63	+ 11·1	24·37	11·4
12	− 6·99	+ 19·2	− 15·17	− 1·9	22·00	10·4
13	− 10·55	+ 4·3	− 16·71	− 14·7	+ 19·50	− 9·4
14	− 12·53	− 11·2	− 17·22	− 26·5	16·88	8·3
15	− 12·70	− 24·9	− 16·70	− 36·7	14·16	7·2
16	− 11·06	− 35·1	− 15·20	− 44·6	11·36	6·0
17	− 7·88	− 40·3	− 12·75	− 49·7	8·49	4·8
18	− 3·60	− 39·8	− 9·52	− 51·7	5·58	3·6
19	+ 1·17	− 33·6	− 5·66	− 50·1	+ 2·65	2·4
20	+ 5·75	− 22·5	− 1·40	− 44·8	− 0·29	− 1·1
21	+ 9·45	− 8·0	+ 2·96	− 36·0	3·22	+ 0·2
22	+ 11·65	+ 7·5	+ 7·01	− 23·7	6·12	1·5
23	+ 11·97	+ 21·7	...	...	8·96	2·8
24	+ 10·32	+ 32·3	...	...	11·7	4·1

Greenwich Noon. 1890.	Titan. a_6-A	δ_6-D	Hyperion. a_7-A	δ_7-D	Iapetus. a_8-A	δ_8-D
	s	''			s	''
May 25	+ 6·97	+ 37·4	...	...	14·40	5·4
26	+ 2·47	+ 36·3	...	...	16·97	6·6
27	− 2·41	+ 29·3	...	...	− 19·42	+ 7·8
28	− 6·90	+ 17·6	...	...	21·73	9·0
29	− 10·32	+ 3·4	...	...	23·88	10·1
30	− 12 20	− 11·3	...	...	25·87	11·2
31	− 12·31	− 24·3	...	...	27·68	12·3
June 1	− 10·69	− 33·7	...	...	− 29·30	+ 13·3
2	− 7·57	38·3	...	...	30·71	14·3
3	− 3·41	− 37·5	...	...	31·92	15·2
4	+ 1·23	− 31·3	...	...	32·92	16·0
5	+ 5·66	− 20·6	...	...	33·70	16·7
6	+ 9·23	− 6·9	...	...	− 34·26	+ 17·4
7	+ 11·33	+ 7·8	...	...	34 60	18·0
8	+ 11·61	+ 21·1	...	...	34·72	18·5
9	+ 9·98	+ 30·8	...	...	34·61	19·0
10	+ 6·71	+ 35·3	...	...	34·29	19·3
11	+ 2·33	+ 34·0	...	...	− 33·76	+ 19·6
12	− 2·41	+ 27·1	...	...	33·02	19·8
13	− 6·75	+ 15·9	...	...	32·08	19·8
14	− 10·06	+ 2·5	...	...	30·95	19·8
15	− 11·87	− 11·3	...	...	29·63	19·7
16	− 11·99	− 23·3	...	...	− 28·14	+ 19·5
17	− 10 39	− 31·9	...	...	26·49	19·2
18	− 7·36	−· 36·0	...	...	24·68	18·8
19	− 3·30	− 34·9	...	...	22·74	18·3
20	+ 1·21	− 28·9	...	...	20·67	17·7
21	+ 5·52	− 18·7	...	...	− 18·50	+ 17 0

Approximate Greenwich times of conjunctions of the satellites with the centre of the planet or of their passages in the direction of the minor axis of the ring.

1890.	h			h			h	
Jan. 1	11·1	Rh. w.	Jan. 2	19·5	Te. n.	Jan. 4	16·2	Mi. n.
	16·1	En. s.	3	6·4	Tit. n. 27″		16·8	Te. n.
	20·4	Mi. n.		11·2	Di. s.		20·0	Di. s.
	20 9	Te. s.		17·3	Rh. e.		20·4	Rh. n.
2	2·4	Di. n.		17·4	En. n.	5	14·9	Mi. n.
	8·5	En. n.		17·6	Mi. n.		15·5	Te. s.
	14·2	Rh. s.		18·2	Te. s.		18·7	En. s.
	19·0	Mi. n.	4	9·8	En. s.		23·5	Rh. w.

1890.	h		1890.	h		1890.	h	
Jan. 6	4·9	Di. s.	Jan. 18	20·5	Te. s.	Jan. 30	10·5	En. s.
	11·1	En. n.	19	4·4	Tit. n. 29″		14·1	Mi. s.
	13·5	Mi. n.		11·5	En. s.		19·4	Rh. e.
	14·1	Te. n.		12·5	Rh. w.		19·8	Di. s.
7	2·6	Rh. s.		18·1	Mi. n.	31	2·9	Te. n.
	12·1	Mi. n.		19·2	Te. n.		12·7	Mi. s.
	12·8	Te. s.		21·2	Di. s.		19·4	En. s.
	13 7	Di. n.		23·1	Tit. ☌ Iap. 0″		22·4	Rb. n.
	20·0	En. n.			? Occultation	Feb. 1	1·6	Te. s.
8	5·6	Rh. e.	20	15·6	Rh. s.		4·6	Di. n.
	10·7	Mi. n.		16·7	Mi. n.		11·4	Mi. s.
	11·4	Te. n.		17·8	Te. s.		11·8	En. n.
	12·5	En. s.		20·4	En. s.	2	0·2	Te. n.
	22·5	Di. s.	21	6·0	Di. n.		1·5	Rh. w.
9	8·7	Rh. n.		8·0	Iap. n. 19″		10·0	Mi. s.
	10·1	Te. s.		12·8	En. n.		13·4	Di. s.
10	7·4	Di. n.		15·3	Mi. n.		20·7	En. n.
	8·7	Te. n.		16·5	Te. n.		22·8	Te. s.
	11·8	Rh. w.		18·7	Rh. e.	3	4·6	Rh. s.
	13 8	En. n.	22	11·0	Rh. ☌ Iap. 1″		13·1	En. s.
11	7·3	Te. s.		13·9	Mi. n.		21·5	Te. n.
	11·6	Tit. s. 29′		14·8	Di. s.		22·3	Di. n.
	14·9	Rh. s.		15·1	En. s.	4	2·2	Tit. n. 31″
	16·2	Di. s.		21·7	En. n.		7·7	Rh. e.
	17·9	Mi. s.		21·8	Rh. n.		20·1	Te. s.
	22·7	En. n.	23	12·5	Mi. n.	5	7·1	Di. s.
12	6·0	Te. n.		13·7	Te. n.		10·8	Rh. n.
	15·1	En. s.		14·1	En. s.		18·8	Te. n.
	16·5	Mi. s.		23·7	Di. n.	6	13·8	Rh. w.
	18·0	Rh. e.	24	0·9	Rh. w.		15·9	Di. n.
13	1·0	Di. n.		6·5	En. n.		17·4	Te. s.
	4·6	Te. s.		11·1	Mi. n.	7	14·3	Mi. n.
	7·5	En. n.		12·4	Te. s.		15·7	En. s.
	15·1	Mi. s.	25	3·9	Rh. s.		16·1	Te. n.
	21·1	Rh. n.		8·5	Di. s.		16·9	Rh. s.
14	3·3	Te. n.		9·7	Mi. n.	8	0·7	Di. s.
	9·9	Di. s.		11·0	Te. n.		8·2	En. n.
	13·7	Mi. s.		15·4	En. n.		13·0	Mi. n.
	16·4	En. n.	26	7·0	Rh. e.		14·7	Te. s.
15	0·2	Rh. w.		7·9	En. s.		20·0	Rh. e.
	1·9	Te. s.		8·4	Mi. s.	9	9·6	Di. n.
	8·8	En. s.		9·7	Te. s.		11·6	Mi. n.
	12·3	Mi. s.		17·3	Di. n.		13·4	Te. n.
	18·7	Di. n.	27	8·3	Te. n.		17·1	En. n.
16	0·6	Te. n.		9·4	Tit. s. 31″		23·1	Rh. n.
	3·3	Rh. s.		10·1	Rh. n.	10	9·5	En. s.
	10·9	Mi. s.		16·7	En. s.		10·2	Mi. n.
	17·7	En. s.		18·3	Mi. s.		12·0	Te. n.
	23·2	Te. s.	28	2·1	Di. s.		18·4	Di. s.
17	3·5	Di. s.		7·0	Te. s.	11	2·2	Rh. w.
	6·3	Rh. e.		9·2	En. n.		8·8	Mi. n.
	9·5	Mi. s.		13·2	Rh. w.		10·7	Te. n.
	10·2	En. n.		16·9	Mi. s.		18·4	En. s.
	20·8	Mi. n.	29	5·6	Te. n.	12	3·2	Di. n.
	21·9	Te. n.		11·0	Di. n.		5·2	Rh. s.
18	9·4	Rh. n.		15·5	Mi. s.		6·9	Tit. s. 34″
	12·3	Di. n.		16·3	Rh. s.		9·3	Te. s.
	19·0	En. n.		18·1	En. n.		10·8	En. n.
	19·5	Mi. n.	30	4·3	Te. s.		18 7	Mi. s.

1890.				
Feb. 13	7·9 Te. n.	Feb. 24	18·7 En. n.	Mar. 8	18·1 Di. n.

1890.

Feb. 13   7·9 Te. n.
     8·3 Rh. e.   ,
     12·0 Di. s.
     17·3 Mi. s.
     19·7 En. n.
  14   6·6 Te. s.
     11·4 Rh. n.
     12·1 En. s.
     15 9 Mi. s.
     20·9 Di. n.
  15   5·2 Te. n.
     14·5 Rh. w.
     14·6 Mi. s.
     21·0 En. s.
  16   3·9 Te. s.
     5·7 Di. s.
     13·2 Mi. s.
     13·4 En. n.
     17·6 Rh. s.
     19·8 ✱8ᵐ precedes
     12··7 on parallel
  17   2·5 Te. n.
     11·8 Mi. s.
     13·0 ✱8ᵐs. 78″
     14·5 Di. n.
     20·7 Rh. e.
  18   1·2 Te. s.
     10·4 Mi. s.
     14·8 En. s.
     23·3 Di. s.
     23·7 Rh. n.
     23·8 Te. s.
  19   7·2 En. n.
     9·0 Mi. s.
     22·5 Te. s.
     23·6 Tit. n. 34″
  20   2·8 Rh. w.
     7·6 Mi. s.
     8·2 Di. n.
     16·1 En. n.
     21·1 Te. n.
  21   5·9 Rh. s.
     8·5 En. s.
     17·0 Di. s.
     17·5 Mi. n.
     19·7 Te. s.
  22   9·0 Rh. e.
     16·2 Mi. n.
     17·4 En. s.
     18·4 Te. n.
  23   1·8 Di. n.
     9·8 En. n.
     12·1 Rh. n.
     14·8 Mi. n.
     17·0 Te. s.
  24   10·6 Di. s.
     13·4 Mi. s.
     15·1 Rb. w.
     15·7 Te. n.

Feb. 24   18·7 En. n.
  25   11·1 En. s.
     12·0 Mi. n.
     14·3 Te. s.
     18·2 Rh. s.
     19·5 Di. n.
  26   10·6 Mi. n.
     13·0 Te. n.
     20·0 En. s.
     21·3 Rh. e.
  27   4·3 Di. s.
     9·2 Mi. n.
     11·6 Te. s.
     12·4 En. n.
  28   0·4 Rh. n.
     4·4 Tit. s. 36″
     7·8 Mi. n.
     10·3 Te. n.
     13·1 Di. n.
     19·2 Mi. s.
     20·8 Tit. ☌ Iap. 19″
Mar. 1   3·5 Rh. w.
     8·9 Te. s.
     12·3 Te. ☌ Iap. 3″
     13·8 En. s.
     17·8 Mi. s.
     21·4 Iap. Transit
         Ingr. 8″ s.
     21·9 Di. s.
  2   2·8 Iap. Transit
         Egr. 6″ s.
     6·5 Rh. s.
     7·6 Te. n.
     10·6 Iap. ☌ prec.
       end of ring 4″ s.
     12·6 Mi. ☌ Iap. 1″
     13·4 Mi. ☌ prec.
       end 4″
     16·9 En. ☌ Iap. 1″
     19·5 En. ☌ prec. end
       6″
     21·8 Te. ☌ Iap. 3″
  3   6·2 Te. s.
     6 8 Di. n.
     9·6 Rh. e.
  4   4·8 Te. n.
     12·7 Rh. n.
     15·6 Di. s.
  5   3·5 Te. s.
     15·8 Rh. w.
  6   0·4 Di. n.
     2·1 Te. n.
     18·9 Rh. s.
  7   0·8 Te. s.
     9·3 Di. s.
     21·1 Tit. n. 36″
     22·0 Rh. e.
     23·4 Te. n.
  8   10·2 En. s.

Mar. 8   18·1 Di. n.
     22·1 Te. s.
  9   1·0 Rh. n.
     18·0 Mi. n.
     19·0 En. s.
     20·7 Te. n.
  10   2·9 Di. s.
     4·1 Rh. w.
     11·5 En. n.
     16·6 Mi. n.
     19·4 Te. s.
  11   7·2 Rh. s.
     11·7 Di. n.
     15·2 Mi. n.
     18·0 Te. s.
  12   10·3 Rh. e.
     12·8 En. s.
     13·8 Mi. n.
     16·7 Te. s.
     20·6 Di. s.
  13   5·2 En. n.
     12·5 Mi. n.
     13·4 Rh. n.
     15·3 Te. s.
  14   5·4 Di. s.
     11·1 Mi. n.
     14·0 Te. s.
     14·1 En. n.
     16·5 Rh. w.
  15   6·5 En. s.
     9·7 Mi. n.
     12·6 Te. n.
     14·2 Di. s.
     19·5 Rh. s.
  16   1·8 Tit. s. 37″
     8·3 Mi. n.
     11·3 Te. s.
     15·4 En. s.
     22·6 Rh. e.
     23·0 Di. n.
  17   6·9 Mi. n.
     7·9 En. n.
     9·9 Te. n.
  18   1·7 Rh. n.
     7·9 Di. s.
     8·5 Te. s.
     16·7 En. n.
     16·8 Mi. s.
  19   4·8 Rh. w.
     7·2 Te. n.
     9·2 En. s.
     15·5 Mi. s.
     16·7 Di. s.
  20   5·8 Te. s.
     7·9 Rh. s.
     14·1 Mi. s.
     18·1 En. s.
  21   1·5 Di. s.
     4·5 Te. n.

1890.	h			h			h	
Mar. 21	10·5	En. n.	Apr. 5	2·7	Di. n.	Apr. 13	7·7	Di. n.
	11·0	Rh. e.		3·2	Rh. n.		14·8	Mi. n.
	12·7	Mi. s.		6·9	Te. n.		17·5	En. n.
22	3·1	Te. s.		12·2	En. n.		18·7	Te. s.
	10·4	Di. n.		14·6	Mi. s.	14	3·9	Rh. n.
	11·3	Mi. s.	6	5·5	Te. s.		9·9	En. s.
	14·1	Rh. n.		6·3	Rh. w.		13·4	Mi. n.
23	1·8	Te. n.		11·5	Di. s.		16·6	Di. s.
	9·9	Mi. s.		13·2	Mi. s.		17·4	Te. n.
	11·8	En. s.	7	4·2	Te. n.	15	7·0	Rh. w.
	17·1	Rh. w.		9·3	Rh. s.		12·0	Mi. n.
	18·9	Tit. n. 37"		11·8	Mi. s.		16·1	Te. s.
	19·2	Di. s.		13·5	En. s.	16	1·4	Di. n.
24	0·4	Te. s.		20·4	Di. n.		10·1	Rh. s.
	8·5	Mi. s.	8	2·8	Te. s.		10·7	Mi. n.
	20·2	Rh. s.		6·0	En. n.		11·3	En. n.
	23·1	Te. n.		7·9	Di. ☌ Iap. 3"		14·7	Te. n.
25	4·0	Di. n.		10·4	Mi. s.		22·1	Tit. s. 38"
	7·2	Mi. s.		12·4	Rh. e.	17	9·3	Mi. n.
	13·1	En. n.		16·9	Tit. n. 37"		10·2	Di. s.
	21·7	Te. s.	9	0·7	Mi. ☌ prec. end 4"		13·2	Rh. e.
	23·3	Rh. e.		0·9	Mi ☌ Iap. 0"		13·4	Te. s.
26	5·6	En. s.		1·5	Te. n.	18	7·9	Mi. n.
	5·8	Mi. s.		1·7	Iap. ☌ prec. end 4" n.		12·0	Te. n.
	12·9	Di. s.		4·7	Iap. occulted by ring. Disapp. 3" n.		12·6	En. s.
	20·4	Te. n.		5·2	Di. s.		16·3	Rh. n.
27	2·4	Rh. n.		9·0	Mi. s.		19·1	Di. n.
	14·5	En. s.		14·9	En. n.	19	10·7	Te. s.
	15·7	Mi. n.		15·5	Rh. n.		19·4	Rh. w.
	19·0	Te. s.		18·8	Iap. ? emerging from behind the ball in the space within the crape ring.	20	3·9	Di. s.
	21·7	Di. n.					9·3	Te. n.
28	5·5	Rh. w.					13·9	En. n.
	6·9	En. n.		23·5	Iap. Reapp. from occultation by the ring 2" s.		16·4	Mi. s.
	14·3	Mi. n.					22·5	Rh. s.
	17·7	Te. n.	10	0·1	Te. s.	21	6·4	En. s.
29	6·5	Di. s.		1·5	Iap. ☌ foll. end of ring 3" s.		8·0	Te. s.
	8·6	Rh. s.		4·6	Te. ☌ Iap. 4"		12·8	Di. n.
	12·9	Mi. n.		7·3	En. s.		15·1	Mi. s.
	15·8	En. n.		7·6	Mi. s.	22	1·6	Rh. e.
	16·3	Te. s.		14·1	Di. n.		6·6	Te. n.
30	8·2	En. s.		18·6	Rh. w.		13·7	Mi. s.
	11·5	Mi. n.		22·8	Te. n.		15·3	En. s.
	11·7	Rh. e.	11	6·3	Mi. s.		21·6	Di. s.
	15·0	Te. n.		16·2	En. s.	23	4·7	Rh. n.
	15·4	Di. n.		21·4	Te. s.		5·3	Te. s.
31	10·2	Mi. n.		21·7	Rh. s.		7·7	En. n.
	13·6	Te. s.		22·9	Di. s.		12·3	Mi. s.
	14·8	Rh. n.	12	8·6	En. n.	24	3·9	Te. n.
	23·6	Tit. s. 38"		16·2	Mi. n.		6·5	Di. n.
Apr. 1	0·2	Di. s.		20·1	Te. n.		7·9	Rh. w.
	12·3	Te. n.	13	0·8	Rh. e.		10·9	Mi. s.
	17·9	Rh. w.					15·3	Tit. n. 36"
2	9·0	Di. s.					16·6	En. n.
	10·9	Te. s.				25	2·6	Te. s.
	21·0	Rh. s.					9·0	En. s.
3	9·6	Te. n.					9·5	Mi. s.
	17·9	Di. s.					11·0	Rh. s.
4	0·1	Rh. e.					15·3	Di. s.
	8·2	Te. s.					16·2	Di. ? Ecl.

F

1890.

	h			h			h	
Apr. 26	1·2	Te. n.	May 10	5·1	Te. s.	May 21	15·5	Di. n.
	8·2	Mi. s.		10·8	En. s.	22	11·7	Te. n.
	14·1	Rh. e.		11·5	Mi. s.		13·7	Rh. s.
	23·9	Te. s.		14·1	Tit. n. 35″	23	0·3	Di. s.
27	0·2	Di. n.		16·6	Di. n.		1·3	Di. ? Ecl.
	17·2	Rh. n.	11	3·8	Te. n.		10·3	Te. s.
	22·6	Te. n.		6·5	Rh. n.		11·3	En. n.
28	9·0	Di. s.		10·1	Mi. s.		16·8	Rh. e.
	10·0	Di. ? Ecl.	12	1·5	Di. s.	24	9·0	Te. s.
	20·3	Rh. w.		2·4	Te. s.		9·2	Di. n.
	21·2	Te. s.		2·5	Di. ? Ecl.		19·9	Rh. n.
29	17·8	Di. n.		8·7	Mi. s.	25	7·6	Te. s.
	19·9	Te. n.		9·6	Rh. w.		18·0	Di. s.
	23·4	Rh. s.		12·2	En. n.		19·0	Di. ? Ecl.
30	18·5	Te. s.	13	1·1	Te. n.		23·0	Rh. w.
May 1	2·5	Rh. e.		10·3	Di. n.	26	6·3	Te. n.
	2·7	Di. s.		12·7	Rh. s.		13·4	Tit. n. 33″
	3·7	Di. ? Ecl.		23·7	Te. s.	27	2·2	Rh. s.
	12·6	Mi. n.	14	13·5	En. s.		2·9	Di. n.
	13·0	En. n.		15·8	Rh. e.		5·0	Te. s.
	17·2	Te. n.		19·2	Di. s.	28	3·6	Te. n.
2	5·6	Rh. n.		20·2	Di. ? Ecl.		5·3	Rh. e.
	11·2	Mi. n.		22·4	Te. n.		11·8	Di. s.
	11·5	Di. n.	15	19·0	Rh. n.		12·8	Di. ? Ecl.
	15·8	Te. s.		21·0	Te. s.	29	2·3	Te. s.
	20·5	Tit. s. 37″	16	4·0	Di. n.		8·4	Rh. n.
3	8·7	Rh. w.		19·7	Te. n.		20·6	Di. n.
	9·8	Mi. n.		22·1	Rh. w.	30	1·0	Te. n.
	14·4	En. s.	17	12·9	Di. s.		11·5	Rh. w.
	14·5	Te. n.		13·9	Di. ? Ecl.		23·6	Te. s.
	20·4	Di. s.		18·4	Te. s.	31	5·5	Di. s.
	21·4	Di. ? Ecl.	18	1·2	Rh. s.		6·5	Di. ? Ecl.
4	6·8	En. n.		14·5	Rh. ☌ Iap. 2″		14·7	Rh. s.
	8·4	Mi. n.		17·0	Te. n.		22·3	Te. n.
	11·8	Rh. s.		19·5	Tit. s. 37″	June 1	14·3	Di. n.
	13·2	Te. s.		21·7	Di. n.		17·8	Rh. e.
5	5·2	Di. n.	19	4·3	Rh. e.		20·9	Te. s.
	7·1	Mi. n.		8·6	En. n.	2	19·6	Te. n.
	11·8	Te. n.		10·0	Iap. ☌ foll.		20·9	Rh. n.
	14·9	Rh. e.			end of ring 4″ s.		23·2	Di. s.
6	8·1	En. s.		14·3	Iap. Transit	3	0·2	Di. ? Ecl.
	10·5	Te. s.			across ring. In-		18·3	Te. s.
	14·1	Di. s.			gress 3″ s.		19·0	Tit. s. 33″
	15·1	Di. ? Ecl.		15·7	Te. s.	4	0·0	Rh. w.
	18·0	Rh. n.	20	2·5	Iap. Egress		8·0	Di. n.
7	9·1	Te. n.			from ball 0″		16·9	Te. n.
	15·6	Mi. s.		6·6	Di. s.	5	3·2	Rh. s.
	17·0	En. s.		7·4	Rh. n.		15·6	Te. s.
	21·2	Rh. w.		7·6	Di. ? Ecl.		16·9	Di. s.
	22·9	Di. n.		8·4	Iap. Transit		17·9	Di. ? Ecl.
8	7·8	Te. s.			across ring.	6	6·3	Rh. e.
	9·5	En. n.			Egress 2″ n.		14·2	Te. n.
	14·2	Mi. s.		9·0	Iap. ☌ prec.	7	1·8	Di. n.
9	0·3	Rh. s.			end of ring. 2″ n.		9·4	Rh. n.
	6·4	Te. n.		13·9	Rh. ☌ Iap.11″		12·9	Te. s.
	7·8	Di. s.		14·3	Te. n.	8	10·6	Di. s.
	8·8	Di. ? Ecl.	21	10·0	En. s.		11·6	Di. ? Ecl.
	12·9	Mi. s.		10·6	Rh. w.		11·6	Te. n.
10	3·4	Rh. e.		13·0	Te. s.		12·5	Rh. w.

1890.
June 9 10·2 Te. s.   June 10 8·9 Te. n.   June 11 5·3 Di. ? Ecl.
        15·7 Rh. s.   18·8 Rh. e.   7·6 Te. s.
        19 5 Di. n.   11 4·3 Di. s.   13·0 Tit. n. 31″

By means of this list of conjunctions approximate values of the co-ordinates x and y of the five inner satellites may be easily found for any other time t with the help of the following little table, the argument of which is the interval τ between the time t and the time of the next preceding or following conjunction, the co-ordinates x and y being expressed in semi-diameters of the planet's equator.

τ	Mimas.		Enceladus.		Tethys.		Dione.		Rhea.	
h	x_1	y_1	x_2	y_2	x_3	y_3	x_4	y_4	x_5	y_5
0	0·0	0·5	0·0	0 7	0·0	0·9	0·0	1·1	0·0	1·6
1	0·9	0·5	0·8	0·7	0·7	0·9	0·6	1·1	0·5	1·6
2	1·7	0·5	1·5	0·6	1·4	0·8	1·2	1·1	1·0	1·6
3	2·3	0·4	2·2	0·6	2·0	0·8	1·8	1·1	1·5	1·5
4	2·8	0·2	2·8	0·5	2·6	0·7	2·4	1·0	2·0	1 5
5	3·1	0·1	3·3	0·4	3·2	0·7	2·9	1·0	2·5	1·5
6	3·1	0 1	3·7	0·3	3·7	0·6	3·5	0·9	3·0	1·5
7	2·9	0·2	3·9	0·2	4·1	0·5	4·0	0·9	3·5	1·4
8	2·5	0 3	4·0	0·0	4·5	0·4	4·4	0·8	4·0	1·4
9	1·8	0·4	4·0	0·1	4·7	0·3	4·8	0·7	4·5	1·4
10	1·1	0·5	3·8	0·2	4·9	0·2	5·2	0·6	4·9	1·3
11					5·0	0·0	5·6	0·5	5·3	1·3
12							5·8	0·5	5·7	1 2
14							6·2	0·3	6·5	1·1
16							6·4	0·0	7·1	0·9

As the latitudes of the inner satellites above the plane of the planet's equator, and also the true extent of the shadow-cone, are not known, it is uncertain when the cycles of the eclipses of the several satellites begin. In the case of *Tethys* the first eclipses are not observable from the Earth, since they take place while the satellite is hidden by the planet. But in the case of *Dione* the satellite remains outside the planet's disc, and it will be worth while to watch it about the times of the heliocentric conjunctions (*Di. ? Ecl.*) given in the list, and to observe some of the earlier eclipses, taking care that the times of the observed disappearances and reappearances should refer to similar phases. Observers with powerful telescopes should look out whether, at the predicted times of "*Te.* n" in February and March, the shadow of *Tethys* can be discerned on the planet's disc. The conjunctions of *Dione* and *Rhea* with the centre of the planet are, during the present apparition of *Saturn*, most favourable for the determination of the orbital longitudes of these satellites, and it would

be a pity if the opportunities for observing them were neglected. By timely publication or communication of their observations of such conjunctions and of conjunctions of *Mimas, Enceladus,* and *Tethys,* with the ends of the ring, observers would have the satisfaction of rendering their contributions available for the proper prediction of the occurrences, which will make the observations of the satellites during the next apparitions of *Saturn* specially interesting.

A look over the ephemeris of *Iapetus* shows how favourable the conditions are for procuring the best direct data for fixing the elements of the satellite's orbit. In order to enable observers to prepare themselves the better for the proper observation of the conjunctions, the co-ordinates x, y of *Iapetus* referred to the axes of the ring are here added. By ascertaining, if feasible, the errors of the predicted places for preceding nights, observers may predict the times of the occurrences more closely than they are given in the list.

Co-ordinates of Iapetus referred to the Axes of the Ring.

0^h Gr. 1890.	x	y	0^h Gr.	x	y
Jan. 19	$-104{\cdot}51$	$+35{\cdot}82$	Apr. 7	$-112{\cdot}14$	$+17{\cdot}14$
20	$-60{\cdot}04$	$28{\cdot}56$	8	$-68{\cdot}62$	$+10{\cdot}62$
21	$-15{\cdot}10$	$21{\cdot}11$	9	$-24{\cdot}85$	$+4{\cdot}07$
22	$+30{\cdot}03$	$13{\cdot}52$	10	$+18{\cdot}91$	$-2{\cdot}47$
23	$+75{\cdot}09$	$+5{\cdot}86$	11	$+62{\cdot}43$	$-8{\cdot}96$
			12	$+105{\cdot}42$	$-15{\cdot}35$
Feb. 28	$+95{\cdot}10$	$-22{\cdot}60$	May 18	$+80{\cdot}33$	$-12{\cdot}79$
Mar. 1	$+47{\cdot}11$	$-14{\cdot}98$	19	$+38{\cdot}04$	$-6{\cdot}70$
	$-1{\cdot}17$	$-7{\cdot}28$	20	$-4{\cdot}36$	$-0{\cdot}56$
	$-49{\cdot}40$	$+0{\cdot}44$	21	$-46{\cdot}59$	$+5{\cdot}55$
4	$-97{\cdot}22$	$+8{\cdot}12$	22	$-88{\cdot}35$	$+11{\cdot}62$

W. H. M. CHRISTIE, M.A., F.R.S., President, in the Chair.

Alfred Fowler, Demonstrator of Astronomical Physics, Normal School of Science, South Kensington, S.W.;

Joseph Kleiber, Privat-Docent of the University of St. Petersburg;

David Smart, L.R.C.P., M.R.C.S., L.S.A., 108 Grange Road, Bermondsey, S.E.,

were balloted for and duly elected Fellows of the Society.

The following Candidates were proposed as Fellows of the Society, the name of the proposer from personal knowledge being appended :—

James Blair Forgan, 15 Pall Mall, S.W. (proposed by C. Piazzi Smyth);

Richard A. Gregory, Assistant Solar Physics Committee, South Kensington, 115 Rylston Road, Fulham, S.W. (proposed by J. Norman Lockyer);

A. N. Harris, hotel keeper, 21 Lambhay Street, Plymouth (proposed by the Rev. J. M. Bacon);

Frederick William Henkel, jun., merchant, 32 Berwick Road, Walthamstow (proposed by J. D. McClure).

On some of the Features of the Arrangement of Stars in Space.
By Edward S. Holden, LL.D., Foreign Associate.

Under ordinary circumstances, observers with equatorial telescopes use eyepieces which have fields hardly larger than 10 or 15 minutes of arc. As a consequence of this, features of the sky which have great extension are utterly lost to them. Long streams of stars (and these are often one, two, or more degrees in length), large nebulæ (such as those of *Orion* and *Andromeda*), and objects of a similar nature are not well seen, and their true relations to the surrounding stars are not discovered. If the telescope is used in sweeps, as was done by Sir William Herschel,

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some of the disadvantages of small fields are done away with by the method of observation itself. I had striking proof of this in my experience with the 15½-inch equatorial of the Washburn Observatory, which was used in this manner. If the observations with small fields, or those made in sweeps, are charted, then some of the larger features of the sky will be reproduced on paper, and can be discovered and studied at leisure.

This method was employed with fruitful results by the late Mr. Proctor.

It may almost be said that only those astronomers who are in the habit of using large fields (and therefore low powers) obtain a vivid idea of the aspect of the larger features of the heavens. Such a vivid conception can always be attained under these circumstances ; but when attained it is almost impossible to convey an accurate notion of it to others without constructing a careful chart of what is seen. This, of course, is usually impossible. I may illustrate my meaning by supposing an observer to be viewing the Milky Way with an eyepiece having a field of 8′ or 10′. The whole field will be filled with stars apparently scattered at random. Neither the stars nor the unoccupied spaces of the background will suggest any order.

Occasionally a double star will pass through the field of view, and the mind at once seizes on this ; for here is a definiteness and order which gives a sense of relief from the chaos of stars among which it chances to fall. Small nebulæ have the same effect. We have certain definite notions about them also. If the eyepiece is changed to one which gives twice or thrice the field of view, and if the observer has acquired the skill to see with this power nearly all that is shown with the higher power, then the sense of order which the mind instinctively seeks for can often be found in the arrangement of the stars themselves. Half a dozen stars in a row pass by with only a moment's attention in the smaller field, but when we see the first six stars succeeded by a stream of six, ten, or twenty more, the attention becomes rivetted on this feature, and there is a positive sense of pleasure in tracing such a stream to its end. Some fields and regions are characterised by streams like this. Others are rich in small definite ellipses of stars, often all of the same size. In some cases stars are surrounded by circles of other fainter stars. In other instances the ellipses become tolerably regular ovals, often of large size. These interlace in the most intricate manner. After having discovered such ovals as these we can frequently trace new and highly interesting features of the kind by paying attention to stars of one magnitude only. If we regard the 11th magnitude stars alone, for example, we may find rings and ovals of these stars forming a regular pattern in the sky. Interlacing with these may be found another pattern of similar ovals (usually smaller) of stars of the 12th magnitude, and so on.

In certain parts of the sky the arrangement is so intricate

that no single pattern can be discovered. In most regions a little attention will show that there are several patterns, one for each of the fainter magnitudes of stars. I have spoken of these patterns and arrangements at some length in the *Century Magazine* for September 1888, and have suggested some consequences which may follow from a study of them. The idea of them was derived from actual observations of the heavens with the equatorial of the Washburn Observatory in 1884 and 1885. It is extremely difficult to convey notions of this sort to a reader, or to anyone who has not the field of stars actually before him in the telescope. At one time I endeavoured to surmount this difficulty by tracing from some of Peters' Ecliptic Charts successively the stars of the 10th magnitude, then those of the 11th, then those of the 12th, and so on. Thus each one of Peters' charts gave me four or five different maps, each containing stars of one magnitude only. Each one of these maps was studied separately, to find out the arrangement or pattern of the stars of that particular magnitude at that particular place; and a comparison of the patterns from two maps threw some light on the question as to whether the stars of the two magnitudes in question were or were not connected in space. Immense pains were necessary in tracing the separate maps, and even after they were made they were not easy to compare.

We have now in photography a means of making these researches in a more satisfactory manner. A series of charts of a given region can be made by giving successive exposures of 30, 60, 90, 150, 180, &c., minutes, with the same lens. It is possible to get excellent definition with a portrait lens over an area of 25 square degrees; and at least tolerable definition can be obtained over 100 square degrees. If the lens is of 6 or 8 inches aperture, stars of the 12th, 13th, or even 14th magnitude can be registered without going to excessively long exposures. In this way, then, we have immense advantages in exhibiting the larger features of the sky. It is only necessary to photograph them, to copy the original negative, and on this copy to mark such lines as will direct attention to the features in question. It will not do so well to simply reproduce the negative. There is an art in examining an astronomical photograph which is akin to the art of observing with an astronomical telescope, although it is easy to acquire, so that it is desirable to indicate the main features in the way I have suggested, and then to leave the eye to trace out the remainder of the figure or pattern. If too many lines are traced on the negative the eye becomes confused. The lines drawn on *negatives* should represent the areas of fewer stars. Lines drawn on *positives* should represent areas of many stars.

Mr. Barnard, of the Lick Observatory, has lately made some very interesting experiments with a portrait lens of nearly 6 inches aperture and 31 inches focus. Some of his photographs of the Milky Way are of extreme beauty. I have examined

these in the manner described, and some of them are reproduced in the accompanying photographs. It must be understood, of course, that these photographs are intended mainly as *diagrams*, to bring out the various patterns which are to be found in the arrangements of the star-groups. The successive copyings of the negative, and especially the interpolation of the guiding lines, have naturally injured the pictorial effect.

Lick Observatory :
    1889 *September* 1.

The following photographs illustrating this paper are placed in the Library :—

    1, 2. Milky Way, R.A. 18ʰ 44ᵐ, Decl.— 6° (Messier 11)
    3, 4. Milky Way, R.A. 17ʰ 56ᵐ, Decl.—28°.
       5. Milky Way, R.A. 18ʰ 11ᵐ, Decl.—20°.
    6, 7. Nebula of Andromeda.

Note on the Spectrum of the Sun-spot of June 1889.
By the Rev. A. L. Cortie, S.J.
(*Communicated by E. W. Maunder.*)

In *Nature* of December 5, 1889, a list of bright lines is given which were observed by Professor Spörer, of Potsdam, on June 28, in a prominence that appeared as the large spot of that month was disappearing over the Sun's edge. The spectrum of this spot in the region D to B was observed at Stonyhurst on June 20, 22, 24, 26, and 27, the instrument used being the Browning automatic spectroscope, with a dispersion of twelve prisms of 60°. Of the seven lines measured by Professor Spörer in the same part of the spectrum of the prominence, excluding D_1, D_2, and C, four are due to calcium, the wave-lengths given being 672·6, 671·6, 649·2. and 646·2. Three other lines of calcium were observed between D and *b*, so that this element was very conspicuous in the prominence. In the spectrum of the spot all the lines given in Ångström's maps as due to calcium were seen to be widened; and of these the lines at 6492·41 and 6461·98, corresponding to Spörer's 649·2 and 646·2. were amongst the most widened lines in the spot, understanding by the term "most widened lines" those lines which were widened more than once their normal breadth. Four other calcium lines were also in this category, their wave-lengths being 6498·25, 6468·78, 6449·29, and 6438·35 respectively, and the widening of the rest was considerable, in no case being less than one-half the normal breadth of the line. Calcium was therefore also very conspicuous in the spectrum of the spot. On June 27 the line at 6492·41—one of the lines seen by Spörer the next day in the prominence—was widened no less than three times its normal breadth. On this day, when the spot was very near the edge of the Sun, several lines were seen to be displaced towards the violet end of the spectrum, among them being the iron lines, 6300·5, 6298·74, 6251·76, 6253·40, and particularly the calcium lines 6101·92 and 6121·34, although no displacement was noted in the calcium

lines seen bright in the prominence by Spörer the next day. It may be remembered that the line 6461·98 is common to the two elements calcium and iron. Besides the four calcium lines and the C line, Spörer also observed the D lines as bright in the prominence. In the spot the D lines were on the 20th nearly reversed, the lines being less dark where they crossed the spot; on the 22nd their widening was estimated as 0·2, while the C line was unaffected in the spot. On the 24th C was less dark over the spot, and D_1 and D_2 were widened 0·3. On the 26th D_1 and D_2 were less dark over the spot and displaced towards the more refrangible end of the spectrum. C was not observed. On the 27th D_1 and D_2 were widened 0·4 and displaced as before. As the spot was very near the Sun's limb, the field of view comprised not only the spot spectrum, but also the ordinary chromospheric lines. The bright line C was very much broadened at the solar limb. It could thence be traced as a bright band over the continuous spectrum right down to the penumbra of the spot. The band was on each side of the dark Fraunhofer line, and between 11 A.M. and noon was broader on the red than on the violet side of the line. The chromospheric line was also slightly displaced in the direction of the red. At 5.30 P.M., though the chromospheric line was not displaced, the bright band was broader on the violet than on the red side of the dark line. The dark line was itself unaffected in the spot, but was almost reversed on the following side of the spot, in all probability in the surrounding faculæ. In the following table are exhibited the results for all the calcium lines in this part of the spectrum :—

TABLE.

Calcium Lines in the Sun-spot of June 1889.

Wave-Length.	Coin-cident Element.	June 20.	June 22.	June 24.	June 26.	June 27.	Prominence (Spörer) June 28.	Remarks.
6726·5	...	...	...	0·5	...	...	bright	
17·16	...	...	...	0·5	...	...	bright	
6498·25	...	1·0	1·0	...	...	...	...	
92·41	...	1·0	1·0	1·5	1·5	3·0	bright	
68 78	...	0·6	...	...	...	•••	...	
61·98	Fe	2·0	0·8	1·0	1 0	1·0	bright	
49·29	Ba	2·0	0·8	1·0	1·0	1·0	...	
38·35	Cd	2·0	0·8	1·0	1·0	1·0	...	
6168·48	...	0·8	...	...	...	...	...	
61·40	...	0·6	...	...	...	•••		
21·34	Co	0·7	...	...	...	0·8	...	{ 27th displaced to violet
01·92	Li	0·5	...	...	...	0·8	...	„ „

Note.—Blanks in the above table do not mean that the line was not widened in the spot. The usual method of observation is first to note all the most widened lines between B and D, and then to observe every line in selected portions of the spectrum.

Spectra of Southern Stars observed at the Melbourne Observatory with the McClean Direct-vision Spectroscope attached to the South Equatorial. Observer, P. Baracchi.

II.

No.	Star's Name	α 1890·0 h m s	N.P.D. 1890·0	Description of Spectra and other Remarks.
1	ε Phenicis	0 3 49	136 21	Yellowish star. Spectrum with very fine dark lines, difficult to see.
2	ι Ceti	0 13 49	99 26	Yellowish star. Spectrum with extremely faint dark lines.
3	π Toucani	0 15 35	160 14	Whitish star. Faint spectrum. Dark lines about F suspected.
4	β Hydri	0 19 51	167 52	Yellowish star. Spectrum with fine dark lines.
5	κ Phenicis	0 20 48	134 18	Whitish star. Spectrum with dark lines about F and G thick and conspicuous. Dark line about C suspected. Violet colour not seen.
6	α Phenicis	0 20 50	132 54	Yellowish star. Spectrum with very fine dark lines, difficult to see.
7	β Toucani	0 26 29	153 34	White; double. Spectrum with dark lines about E, b, F, and G. G difficult. Violet hardly seen. E and b very faint. F thick and distinct.
8	Stone 194	0 27 43	153 38	White star. Spectrum with dark lines about F and G, thick and very distinct.
9	β Ceti	0 38 4	108 35	Spectrum with dark lines about C, E, b, F, G, and other very faint ones. Yellowish star.
10	β Phenicis	1 1 11	137 18	White star tending to yellow. Spectrum with dark lines about F and G, and others suspected. Violet not seen.
11	η Ceti	1 3 3	100 46	White star. Spectrum with dark lines at F and G well seen. G very broad and diffused. Dark lines about C, E, and b suspected. Blue colour preponderates.
12	ν Phenicis	1 10 13	136 7	Whitish star. Spectrum with a broad, nebulous, dark band about G. Dark lines suspected. F pretty well seen. No violet.
13	θ Ceti	1 18 31	98 45	Yellowish star. Spectrum with very faint dark lines suspected.

No.	Star's Name.	α 1890·0. h m s	N.P.D. 1890·0. ° ′	Description of Spectra and other Remarks.
14	γ Phenicis	1 23 36	133 53	Spectrum with several dark lines. One very thick and black in the red; one in the orange also thick and well defined; a fainter one in the yellow; one about F tolerably conspicuous; several very fine and faint in the blue.
15	δ Phenicis	1 26 40	139 39	White star tending to yellow. Spectrum with fine dark lines suspected.
16	α Eridani	1 33 37	147 48	White star. Spectrum with dark lines about C, F, G, and one in the violet. C only visible at the edges of the spectrum; the others very distinct and prominent.
17	τ Ceti	1 38 59	106 31	Yellowish star. Spectrum with dark lines suspected.
18	χ Eridani	1 51 37	142 9	Continuous spectrum.
19	α Hydræ	1 55 17	152 6	Spectrum with dark lines about F and G.
20	υ¹ Eridani	4 13 44	124 4	White star. Spectrum with dark lines about E, F, and G. Other faint dark lines suspected.
21	υ² Eridani	4 19 54	124 16	Spectrum with dark lines about C, F, and G.
22	α Argus	6 21 31	142 38	Spectrum with dark lines; two of these are about F and G prominent and thick. Suspected bright band in the yellow (?) Blue and violet occupy together one-half, and the yellow and red together only one-fifth part of the whole length of the spectrum; the rest being taken by the green and greenish blue.
23	α Carinæ	9 8 4	148 31	Continuous spectrum. Green colour in large proportion. Violet not seen.
24	ν Argus	9 44 21	154 34	Spectrum with one dark line in the middle of the green. Other faint dark lines suspected.
25	ω Argus	10 11 7	159 29·5	Continuous spectrum.
26	θ¹ Crucis	11 57 26	152 42	Continuous spectrum. Blue and green preponderate. Violet not seen.
27	θ² Crucis	11 58 40	152 33	Continuous spectrum. ,, ,, ,,
28	ζ Crucis	12 12 29	153 23	Continuous spectrum. ,, ,, ,,
29	ι Crucis	12 39 10	150 23	Continuous spectrum. ,, ,, ,,
30	κ Crucis	12 47 15	149 47	Continuous spectrum. ,, ,, ,,

No.	Star's Name.	α 1890·0. h m s	N.P.D. 1890·0.	Description of Spectra and other Remarks.
31	Stone 7112	12 48 8	146 35	Continuous spectrum. Blue and green preponderate. Violet not seen.
32	Stone 7113	12 48 9	146 34	Continuous spectrum. " " "
33	Stone 7119	12 49 29	146 14	Continuous spectrum. " " "
34	Stone 7208	13 0 37	149 16	Continuous spectrum. " " "
35	Stone 7238	13 5 26	149 20	Continuous spectrum. " " "
36	Stone 7244	13 6 3	149 14	Continuous spectrum. " " "
37	Stone 7253	13 7 27	148 31	Continuous spectrum. " " "
38	β Centauri	13 56 3	149 50	Yellowish star. Spectrum with dark lines. One extremely faint about C, only seen at the edges of the spectrum; one in the yellow about D as faint; one about G quite distinct and well defined, not thick; two far in the violet, uncertain; three extremely faint and diffused in the greenish blue. Yellow and green in large proportion.
39	ι Virginis	14 10 15	95 28	White star. Spectrum with dark lines suspected about C, F, and G. Bluish tint extending over green and yellow; violet hardly seen.
40	λ Virginis	14 13 9	102 52	Spectrum with dark lines about C, F, and G; F very thick and prominent; G faint and diffi-cult; C only suspected. Bluish tint extending over a great portion of the spectrum; violet colour hardly seen.
41	μ Virginis	14 37 16	95 11	White star. Spectrum with a dark line about F suspected. Bluish tint extending over a great portion of the spectrum.
42	α Libræ	14 44 48	105 35	White star. Spectrum with dark lines about C, F, and G; the two last very thick and pro-minent. C only visible at the edges of the spectrum. Bluish tint pervades.
43	β Lupi	14 51 20	132 41	Continuous spectrum.
44	δ Libræ	14 55 6	98 5	Yellowish star. Spectrum with extremely fine dark lines suspected.
45	β Libræ	15 11 5	98 59	White star. Spectrum with dark lines about C, F, and G, and one far in the violet. Several extremely fine dark lines in the bluish green suspected.
46	2 Lupi	15 11 8	119 45	Yellowish star. Continuous spectrum.

No.	Star's Name.	α 1890·0. h m s	N.P.D. 1890·0.	Description of Spectra and other Remarks.
47	ζ Libræ	15 22 3	106 20	Yellowish star. Continuous spectrum.
48	37 Libræ	15 28 8	99 41	White star. Spectrum very faint; the four hydrogen lines suspected. Bluish tint pervades the spectrum.
49	γ Libræ	15 29 22	104 25	White star tending to yellowish. Spectrum with faint dark lines suspected. Blue predominates; yellow and violet not seen.
50	η Libræ	15 37 53	105 19	White star. Continuous spectrum. Blue predominates; violet not seen.
51	μ Serpentis	15 43 53	93 6	White star. Spectrum with a dark line about F. Bluish tint pervades the spectrum.
52	β Trianguli	15 45 29	153 5	Spectrum with many faint dark lines; one dark line about F more prominent.
53	λ Libræ	15 46 57	109 50	White star. Continuous spectrum. Blue colour abounds; violet and yellow hardly seen.
54	θ Libræ	15 47 33	106 24	White yellowish star. Continuous spectrum. Blue tinge pervding the spectrum; violet and yellow not seen.
55	48 Libræ	15 52 2	103 58	White bluish star. Continuous spectrum. Bluish tint pervading the spectrum; violet not seen.
56	π Scorpii	15 52 12	115 48	Spectrum with very fine lines suspected. Violet abounds.
57	β Scorpii	15 59 2	109 30	Continuous spectrum.
58	ν Scorpii	16 5 36	109 10	White star. Continuous spectrum. Slight tinge of blue over green and yellow.
59	δ Ophiuchi	16 8 35	93 25	White yellowish star. Spectrum with extremely fine dark lines in the blue, and one about C.
60	ε Ophiuchi	16 12 30	94 25	Yellowish star. Spectrum with very fine faint lines difficult to see.
61	σ Scorpii	16 14 30	115 20	White star. Continuous spectrum. Violet colour in large proportion.
62	ψ Ophiuchi	16 17 40	109 47	Continuous spectrum. Red very intense.
63	χ Ophiuchi	16 20 39	108 12	Continuous spectrum. Red in large proportion.
64	Scorpii, B.A.C. 5508	16 24 12	124 28	White bluish star. Spectrum with dark lines about C, F, and G suspected. Bluish tinge extending over a great part of the spectrum.
65	23 τ Scorpii	16 29 2	117 59	Whitish star. Spectrum with very fine dark lines suspected. Bluish tinge pervading.

No.	Star's Name.	α 1890·0. h m s	N.P.D. 1890·0.	Description of Spectra and other Remarks.
66	Aræ B.A.C. 5554 }	16 33 18	150 42	Spectrum extremely faint—beyond reach of the instrument. Star 6½ mag.
67	η Ophiuchi	17 4 4	105 35	Spectrum with dark lines; one about C faint; one about G thick and prominent, and a similar one in the violet.
68	36 θ¹ Ophiuchi	17 8 35	116 26	Faint spectrum with many very fine and faint dark lines in the red and blue suspected.
69	ζ Apodis	17 10 30	157 39	Yellowish star. Continuous spectrum.
70	41 Ophiuchi	17 10 58	90 19	White star. Spectrum with dark lines about C, F, and G uncertain. Spectrum very faint. Violet colour not seen.
71	ξ Ophiuchi	17 14 24	111 0	Spectrum with dark lines about F and G. Others suspected. Blue colour predominates.
72	Stone 9445	17 14 57	114 48	Yellowish star. Spectrum with very fine dark lines suspected.
73	θ Ophiuchi	17 15 15	114 53	White bluish star. Spectrum with dark lines about C, F, G, and H; the last two very distinct; the others uncertain. Bluish tint over a great portion of the spectrum.
74	γ Aræ	17 16 8	146 16	Continuous spectrum. Blue and green occupy three-fourths of the total length.
75	45 Ophiuchi	17 20 21	119 46	White bluish star. Spectrum with dark lines about F and G. Blue preponderates.
76	υ Scorpii	17 23 17	127 12	Spectrum with several very faint dark lines suspected in the red and orange, and one near G.
77	α Aræ	17 23 21	139 47	White star. Continuous spectrum. Slight tinge of blue seems to extend over the green and yellow.
78	Stone 9585	17 28 58	128 33	Spectrum with three uncertain bands or groups of dark lines about E, F, and G.
79	ξ Serpentis	17 31 17	105 20	Spectrum with dark lines. A fine one about C; one broad and marked about G; one also broad, but not so marked, far in the violet.
80	ι Scorpii	17 39 54	130 5	Continuous spectrum. Yellow colour almost totally absent.
81	Scorpii, B.A.C. 6018 }	17 42 22	127 0	Yellowish star. Spectrum with many very faint dark lines difficult to see.
82	ν Ophiuchi	17 52 58	99 46	Yellowish star. Continuous spectrum.
83	π Pavonis	17 57 59	153 40	White star. Spectrum with dark lines about C, F, and G. The C line very difficult. F and G very thick and prominent.

No.	Star's Name.	α 1890·0. h m s	N.P.D. 1890·0. ° ′	Description of Spectrum and other Remarks.
84	θ Aræ	17 58 4	140 6	White star. Spectrum with fine dark lines suspected.
85	ε Telescopii	18 3 4	135 58	Yellowish star. Continuous spectrum.
86	μ Sagittarii	18 7 11	111 5	Whitish star. Spectrum with excessively fine dark lines very difficult to see.
87	η Serpentis	18 15 37	92 56	Yellowish star. Continuous spectrum.
88	α Telescopii	18 18 49	136 2	White star. Spectrum with dark lines about F and G faint; other lines suspected.
89	ζ Telescopii	18 20 21	139 8	Yellowish star. Continuous spectrum.
90	λ Sagittarii	18 21 11	115 29	Spectrum with extremely fine lines suspected.
91	ζ Pavonis	18 30 11	161 31	White yellowish star. Spectrum with very fine dark lines.
92	ξ Sagittarii	18 55 37	120 2	White bluish star. Spectrum with dark lines about C, F, G, and one in the violet. C difficult; F very thick and prominent.
93	ε Pavonis	19 47 51	163 12	White bluish star. Spectrum with dark lines about C, F, and G. C double line difficult; F very broad but not prominent. Faintly defined.
94	α Pavonis	20 16 56	147 5	Spectrum with dark bands and lines. Very thick dark band or group of dark lines far in the violet. Other similar band about G not so thick and rather indistinct. Dark band or group of dark lines about F. This is the best defined, but not conspicuous.
95	α Toucani	22 10 58	150 48	Spectrum with dark lines about F and G well seen; others uncertain. White star.
96	γ Aquarii	22 15 58	91 56	White bluish star. Spectrum with dark lines about C, F, and G, and other fainter ones suspected in the blue. Bluish tinge over spectrum.
97	55 ζ Aquarii	22 23 10	90 35	White bluish star. Spectrum with dark lines about F and G, and others suspected in the blue. F thick. Bluish tinge over spectrum.
98	δ² Gruis	22 23 11	134 19	Spectrum with flutings; two in the red very marked; a fainter one in the yellow; three very prominent in the blue. Several dark bands in the violet, and many fine dark lines all over. Flutings fade away towards the red end of the spectrum.
99	η Aquarii	22 29 42	90 41	White bluish star. Spectrum with dark lines about F and G; both thick. Several other faint dark lines in the green and blue.
100	λ Aquarii	22 46 52	98 10	Yellowish star. Spectrum with many dark lines in all colours, several of which are very prominent, like the solar spectrum.

Spectroscopic Observations of the Motion of Stars in the Line of Sight made at the Temple Observatory, Rugby. By Geo. M. Seabroke.

The following observations are intended to be in continuation of similar ones communicated to the Society in the years 1879 and 1887; and in vol. xlvii. page 93 of the *Monthly Notices* will be found a description of the telescope and spectroscope used prior to the commencement of the present year.

Those observations recorded as made with two prisms are made with a new spectroscope constructed by me some months ago, and consisting of a collimator of 18 inches focal length and $1\frac{1}{2}$ inch in diameter, a similar lens in the observing telescope, and two prisms of an angle of 45°. The focal length of the eye-piece is about $\frac{1}{3}$ inch.

The measures were made by a pointer of tinfoil, set edgewise to the line of sight, alternately on the star line and line from the hydrogen tube or magnesium wire respectively, and recording the distance moved by the pointer by readings of the micrometer screw.

The pointer is illuminated by light reflected upon it from a small reflector close to the eye.

Owing to my want of practice with a pointer of this form, and certain wants of adjustment in illuminating the pointer equally at both edges, my early readings vary *inter se*, and the observations are therefore of little value; but of late the measures are much more accordant. By reducing the number of prisms in the new instrument as compared with the old one, the illumination of the spectrum is much increased, while the power of comparison is retained by increase of focal length and diameter of the collimator.

A marked excess of − motion over + is to be remarked; and although I can give no reason for any systematic error in the former direction, I feel that the observations hereafter recorded should be received with caution.

Number of Prisms.	Line Compared.	Number of Measures.	Cor. Motion in Miles per Second.	Date 1800+	Remarks.
			Andromedæ.		
5	F	4	+32·6	87·084	
5	F	3	−46·7	·928	
5	F	4	−29	·955	
5	F	3	−68·8	·958	
2	F	2	−56·2	88·972	
2	F	4	−30·5	89·825	
			γ Pegasi.		
5	F	4	−51·2	87·903	
5	F	3	−23·1	·955	

Number of Prisms.	Line Compared.	Number of Measures.	Cor. Motion in Miles per Second.	Date 1800+	Remarks.
			β Andromedæ.		
5	F	2	+ 13·7	87·084	
5	F	4	− 37·9	·110	
5	F	3	− 35·5	·120	
5	F	3	− 16·3	·125	
			β Arietis.		
5	F	3	− 46·1	87·928	
5	F	4	− 62·6	88·076	
5	F	1	− 34·5	·024	
			γ Andromedæ.		
5	F	3	− 45·2	87·084	
5	F	4	− 38·9	·110	
5	F	3	− 27·2	·125	
5	F	2	− 38·7	88·172	
			a Arietis.		
5	F	4	− 47·9	87·084	
5	F	2	− 34·5	·104	
5	F	4	− 36·7	·110	
5	F	3	− 32	·120	
5	F	2	− 30·9	·928	
5	F	3	− 20·5	88·076	
			Algol.		
5	F	4	− 28·2	87·125	
5	F	5	− 45·2	·150	
5	F	3	− 51·1	·158	
5	F	2	− 39·4	·167	
5	F	4	− 22·5	·928	
5	F	3	− 31·2	88·076	
5	F	5	− 54·6	·172	
5	F	3	− 47.5	·197	
2	F	3	− 88·5	89·123	
			a Persei.		
5	F	4	− 35·4	87·110	
5	F	3	− 44·7	·120	
5	F	6	− 37·7	88·172	
5	F	1	− 33·0	·197	

Number of Prisms.	Line Compared.	Number of Measures.	Cor. Motion in Miles per Second.	Date 1800+	Remarks.
			Aldebaran.		
5	F	3	+ 8·7	87·158	
5	F	3	+ 7·7	88·172	
5	F	1	− 7·3	·197	
			α Aurigæ.		
5	F	3	− 59·4	87·120	
5	F	5	− 36	·125	
5	F	1	− 18·3	·150	
5	F	2	− 12·5	·158	
5	F	4	− 3	·287	
5	F	4	− 22	·298	
5	F	5	− 13	88·172	
5	F	2	+ 8·5	·314	
5	F	4	+ 5	·328	
5	F	4	+ 12	·334	
2	F	5	− 41·3	89·123	
5	F	3	+ 13·7	·227	
5	F	4	− 39·8	·238	
			Rigel.		
5	F	2	+ 21·6	87·084	
5	F	4	+ 0·9	·110	
5	F	2	+ 2·3	·104	
5	F	4	+ 2·5	88·197	
5	F	2	− 3·5	·216	
			γ Orionis.		
5	F	3	− 24	87·158	
5	F	3	− 8·5	88·197	
			β Aurigæ.		
5	F	4	− 42·7	87 287	Line diffuse.
5	F	4	− 55·3	88·328	,,
5	F	2	− 41·2	·334	
5	F	4	− 54·3	·347	
5	F	3	− 62	89 227	
			β Tauri.		
5	F	3	+ 5·8	87·287	
5	F	4	+ 21·1	·298	

Number of Prisms.	Line Compared.	Number of Measures.	Cor. Motion in Miles per Second.	Date 1800+	Remarks.
			Sirius.		
5	F	3	— 44·1	87·110	
5	F	2	— 22·5	·125	
5	F	4	·· 31·3	·150	
5	F	3	— 47·7	·158	
5	F	4	— 19·5	88·172	
5	F	2	— 38·7	·199	
5	F	4	— 49·8	·216	
2	F	6	—174·6	89·104 ⎫	New spectroscope ,
2	F	...	—123·7	·123 ⎭	obviously in error.
			Castor.		
5	F	3	— 14	87·287	
5	F	4	—51·7	·350	
5	F	3	—49·4	·353	
5	F	3	—48·6	88·314	
5	F	4	—25·9	·328	
5	F	2	— 4·2	·334	
5	F	4	+ 12·7	·347	
2	F	3	— 148	89·227	New spectroscope ; error.
			Procyon.		
5	F	3	— 10·8	87·287	
5	F	5	—21·6	·298	
5	F	3	—37 5	·350	
			Pollux.		
5	F	2	—18·2	87·353	
5	F	3	+ 2·9	88·314	
5	F	2	—48·6	·328	
5	F	1	—22·8	·334	
5	F	4	—33 4	·347	
			η Leonis.		
5	F	2	o	88·334	

Number of Prisms.	Line Compared.	Number of Measures.	Cor. Motion in Miles per Second.	Date 1800 +	Remarks.
			α Leonis.		
5	F	7	−21·5	87·350	
5	F	6	−47·2	·353	
5	F	4	+22·9	·374	
5	F	4	− 7·0	88·325	
5	F	5	−68·5	·328	
5	F	4	−58·3	89·232	
5	F	4	−36·4	·342	
5	F	2	−27	·382	
5	F	4	−40·6	·383	
			γ Leonis.		
5	F	1	− 0·3	87·350	Line barely visible.
5	F	4	−15·8	88·394	,, ,,
			α Ursæ Majoris.		
5	F	5	+ 5·5		
5	F	4	− 4·1		
			γ Ursæ Majoris.		
5	F	4	−26·6	87·520	
5	F	4	−19·3	·550	
5	F	4	−31·5	89·386	
2	F	4	85·5	·388	Line badly defined.
2	F	3	−75·8	·427	New spectroscope ; probably in error.
			β Ursæ Majoris.		
5	F	3	− 9·5	87·52	
5	F	4	+ 3·0	·55	
5	F	3	− 45·8	89·386	
5	F	5	− 64·7	·388	
2	F	4	− 39	·427	
2	F	4	− 82	·446	
			δ Leonis.		
5	F	3	− 24	88·394	Line diffuse.
5	F	4	−107	89·380	,,
5	F	4	− 74·6	·383	,,
			θ Leonis.		
5	F	4	− 24	...	Line faint.
5	F	3	− 35	...	,,
5	F	4	+ 12·7	...	

Number of Prisms.	Line Compared.	Number of Measures.	Cor. Motion in Miles per Second.	Date 1800+	Remarks.
			β Leonis.		
5	F	5	− 30·8	87·443	Line very diffuse.
5	F	5	− 19·3	88·394	
5	F	4	− 83·5	89·380	
5	F	4	− 32·2	·383	
			δ Ursæ Majoris.		
5	F	3	− 33·9	87·520	
5	F	4	− 10·8	·550	
2	F	2	− 33·0	89·418	
			ε Ursæ Majoris.		
5	F	4	− 15·3	87·484	
5	F	4	− 19·8	·520	
5	F	3	− 19·7	·580	
5	F	4	− 55	89·386	
5	F	4	− 95·5	·388	
2	F	3	− 40·2	·418	
2	F	4	− 83·2	·465	
			ξ Ursæ Majoris.		
5	F	4	− 11·6	87·550	
5	F	5	− 42·2	·580	
5	F	3	− 61·3	89·386	
2	F	5	− 21	·465	
			α Virginis.		
5	F	4	− 17·1	87·353	
5	F	4	− 0·5	·374	
5	F	7	− 51·9	·443	
5	F	3	− 4·2	89·383	
			η Ursæ Majoris.		
5	F	3	− 28·5	87·457	
5	F	3	+ 2·7	·550	
5	F	4	+ 1·3	·580	
5	F	2	− 28·9	·640	
5	F	2	− 32·5	89·383	
2	F	4	− 65·5	·418	New spectroscope; doubtful.
2	F	5	− 7·7	·468	,,

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Number of Prisms.	Line Compared.	Number of Measures.	Cor. Motion in Miles per Second.	Date 1800+	Remarks.
			Arcturus.		
5	b_1	5	+ 7·1	87·353	
5	b_1	6	+ 8·1	·374	
5	b_1	4	− 44·3	·434	
5	b_1	4	− 28·1	·443	
5	b_1	2	− 23·1	·451	
5	F	1	− 35·0	88·380	
			a Coronæ Borealis.		
5	F	4	− 11·3	87·550	
5	F	5	− 57·4	·640	
5	F	2	− 22·2	·680	
5	F	4	− 35·7	·750	
5	F	1	− 45·0	89·380	
2	F	2	− 56·5	·427	
2	F	5	− 59·3	·506	
2	F	4	+ 9·0	·544	
			a Ophiuchi.		
5	F	2	− 20·8		
5	F	3	− 25·7		
5	F	4	+ 9·0		
2	F	4	+ 23·0	...	New spectroscope; doubtful.
			Vega.		
5	F	6	+ 24·0	87·740	
5	F	5	− 64·1	·770	
5	F	5	− 53·1	·791	
5	F	3	− 29·7	·802	
5	F	3	− 56·0	·810	
5	F	5	− 67·1	·829	
5	F	4	− 21·2	88·794	
5	F	3	− 33·7	·796	
5	F	4	− 43·0	·804	
2	F	5	− 39·6	89·506	
2	F	4	− 55·0	·544	
2	F	4	− 63·3	·654	
2	F	4	− 50·1	·657	
2	F	4	− 73·2	·659	
2	F	3	− 46·5	·681	

Number of Prisms.	Line Compared.	Number of Measures.	Cor. Motion in Miles per Second.	Date 1800+	Remarks.
			γ *Lyræ.*		
5	F	5	+ 6·3	87·791	
5	F	3	− 33·4	·802	
5	F	3	− 27·5	·810	
5	F	2	− 27·5	·829	
5	F ·	2	− 14·8	88·796	
5	F	3	− 72·5	·804	
			ζ *Aquilæ.*		
5	F	3	− 27·9	87·791	
5	F	4	− 15·5	·802	
5	F	4	− 51·9	·810	
			γ *Aquilæ.*		
5	F ·	3	− 24·6	87·802	
5	F	4	+ 4·7	·810	
			δ *Cygni.*		
5	F	4	+ 14	87·791	
5	F	4	− 29·7	·802	
5	F	4	− 25·0	·810	
5	F	4	− 30·4	·903	
5	F	3	− 28·1	88·796	
2	F	3	− 53·5	89·679	New spectroscope; doubtful.
2	F	5	− 49·5	·690	,,
			Altair.		
5	F	4	− 23·5	87·791	
5	F	4	− 28·3	·810	
5	F	3	− 34·5	88·794	
5	F	4	− 39·5	·796	
5	F	2	− 82·7	·804	
2	F	4	+ 2·5	89 796	
2	F	4	− 34·5	·659	
			θ *Aquilæ.*		
3	F	8	+ 34·5	86·75	

Number of Prisms.	Line Compared.	Number of Measures.	Cor. Motion in Miles per Second.	Date 1800+	Remarks.
			γ *Cygni.*		
5	F	4	− 22·0	86·96	
5	F	4	− 31·4	·96	
5	F	4	− 47·1	87·791	
5	F	3	− 24·2	·802	
5	F	4	− 37·2	·810	
2	F	3	− 21·0	89·777	
2	F	4	− 34·5	·796	
			α *Cygni.*		
3	F	4	− 17·0	86·93	
5	F	4	− 36·5	·96	
5	F	4	− 55·3	·96	
5	F	3	+ 21·1	87·791	
5	F	4	− 28·3	·870	
5	F	4	− 25·3	·903	
5	F	3	− 20·4	88·794	
5	F	2	− 58·0	·796	
2	F	5	− 16·0	89·777	New spectroscope ; doubtful.
2	F	4	+ 7·0	·796	.,
			ε *Cygni.*		
3	F	2	− 27·0	86·93	
5	F	4	− 33·9	87·810	
5	F	2	− 16·3	·955	
2	F	3	− 39·0	89·796	
			ε *Pegasi.*		
5	F	4	+ 10·3	87·902	
5	F	4	+ 6·7	·955	
5	F	4	+ 10·2	·958	
			η *Pegasi.*		
3	F	2	− 17·7	86·93	
			α *Pegasi.*		
5	F	2	− 26·3	86·96	
5	F	5	− 27·8	87·870	
5	F	4	− 40·5	·903	
5	F	3	− 38·0	·950	
5	F	4	− 17·0	·955	
2	F	3	− 47·0	89·177	
2	F	4	+ 10·0	·835	
			β *Pegasi.*		
5	b_1	2	+ 41·1	86·96	
5	b_1	2	+ 16·6	·96	

On the Orbit of Struve 228.   By J. E. Gore.

Recent measures show that this binary star has described about 120° of its apparent orbit since its discovery by Struve in 1829. I have computed the orbit by Professor Glasenapp's method, combined with Kowalsky's equations, and find the following provisional elements :—

Elements of Σ 228.

$$P = 88 \cdot 73 \text{ years} \qquad \Omega = 84° \ 49'$$
$$T = 1906 \cdot 03 \qquad\qquad \lambda = 51° \ 36'$$
$$e = 0 \cdot 5311 \qquad\qquad a = 0'' \cdot 98$$
$$i = 70° \ 59' \qquad\qquad \mu = +4° \cdot 057$$

P and T were computed by the formulæ :—

$$T = \frac{t' + t}{2} - \frac{M' + M}{M' - M} \cdot \frac{t' - t}{2}$$

$$P = \frac{360°}{\mu} \ ; \ \mu = \frac{M' - M}{t' - t}$$

where M and M' are the mean anomalies, computed from the geometrical elements, for the epochs t and t' and the corresponding values of θ, derived from the earlier and later observations.

The following is a comparison between the recorded measures and the positions computed from the above elements. The observed position-angles have been corrected for the effect of precession to 1880·0 :—

Epoch.	Observer.	θ_o	θ_c	$\theta_o - \theta_c$	ρ_o	ρ_c	$\rho_o - \rho_c$
1829·16	Struve	264·21	258·47	+ 5·74	1·08	0·83	+ 0·25
1831·75	,,	262·41	262·50	− 0·09	1·22	0·96	+ 0·26
1832·02	,,	259·00	262·80	− 3·80	1·14	0·99	+ 0·15
1832·20	,,	263·50	263·00	+ 0·50	0·93	1·05	− 0·12
1832·21	,,	262·60	263·01	− 0·41	1·03	1·05	− 0·02
1841·94	O. Struve	274·88	271·36	+ 3·52	1·32	1·20	+ 0·12
1852·19	Mädler	280·32	278·80	+ 1·52	1·11	1·18	− 0·07
1856·76	Dembowski	281·12	282·48	− 1·36	1·0	1·12	− 0·12
1857·21	Mädler	284·23	282·87	+ 1·36	0·9	1·11	− 0·21
1862·96	Dembowski	286·57	288·57	− 2·00	0·9	0·98	− 0·08
1866·07	,,	291·66	292·45	− 0·79	0·947	0·89	+ 0·057
1869·48	Dunér	299·54	297·64	+ 1·90	0·71	0·78	− 0·07
1870·18	O. Struve	299·64	298·93	+ 0·71	0·86	0·76	+ 0·10
1873·81	Dembowski	304·40	306·80	− 2·40	0·64	0·65	− 0·01
1874·94	Gledhill	307·22	309·83	− 2·61	0·6	0·61	− 0·01

Epoch.	Observer.	θ_0	θ_c	$\theta_0 - \theta_c$	ρ_0	ρ_c	$\rho_0 - \rho_c$
1875·20	Dunér	311·42	310·58	+ 0·84	0·52	0·60	– 0·08
1876·89	Dembowski	314·92	315·85	– 0·93	0·522	0·55	– 0·028
1878·90	Doberck	327·71	323·92	+ 3·79	0·47	0·49	– 0·02
1883·50	Engelmann	348·29	349·41	– 1·12	0·311	0·40	– 0·089
1888·142	Schiaparelli	33·60	22·33	+ 11·27	0·35	0·39	– 0·04
1888·171	Tarrant	17·23	22·54	– 5·31	0·43	0·39	+ 0·04
1888·696	,,	21·31	26·10	– 4·79	0·40	0·40	0·00
1888·778	,,	21·54	26·61	– 5·07	0·46	0·40	+ 0·06
1888·931	Schiaparelli	25·73	27·63	– 1·90	0·36	0·40	– 0·04
1889·018	,,	30·25	28·23	+ 2·02	0·35	0·40	– 0·05
1889·021	Young	34·56	28·24	+ 6·32	0·41	0·40	+ 0·01
1889·570	Tarrant	26·97	31·76	– 4·79	0·37	0·41	– 0·04

The recent measures by Professors Schiaparelli and Young and Mr. Tarrant were kindly communicated to me by private letter.

According to the above orbit the distance between the components will gradually increase during the next few years, up to a maximum of about 0″·55, and then diminish again as the companion approaches the periastron. The minimum distance will not be reached till the position-angle is nearly 180° (after the periastron passage), when the components will probably be separated by less than 0″·2. Careful measures during the next sixteen years will be very valuable for correction of the provisional elements.

On the supposition that the combined mass of the components is equal to the mass of the Sun, the "hypothetical" parallax would be

$$\pi = a\,P^{-\frac{2}{3}} = 0''·05$$

The binary lies a little preceding 62 *Andromedæ*, and its position for 1890·0 is approximately :—

$$\text{R.A. } 2^{h}\ 6^{m}\ 59', \text{ Decl.} + 46°\ 58''·4$$

The magnitudes of the components are about 6·7 and 7·6.

A Method of Recording the Transits of Stars by Photography.
By W. E. Wilson.

I wish to bring before the notice of the Society a method by which the transits of stars can be recorded by photography and the personal errors eliminated. If a sensitive photographic plate is placed in the focus of a transit instrument close behind the wires, and the image of a star of suitable magnitude allowed to transit across it, the result is a straight black line on developing the

plate. If instead of having the plate fixed, we have it so arranged that it can be given a small up-and-down motion each second, the result on the plate is a broken line, thus, ‾_‾‾ _‾_‾_, the breaks in which are equal to seconds of time. The motion is given to the plate by an electro-magnet driven by a current sent by the observatory clock. During or after the transit a light from a small electric lamp is allowed to fall through the object-glass on the plate for a few seconds. This gives an impression of the wires superposed on the star transit. With a rough apparatus I find the time of transit can be recorded to $\frac{1}{4}$ second, and I believe with some care the time could be taken to a very small fraction of a second.

I used for these experiments the 4-inch finder of my 2-foot reflector. The object-glass was not corrected for photographic rays, and the star trail on the plate was therefore not as fine as it would be with a suitable objective.

1889 *December* 12.

Catalogue of Bright Meteors observed at Bristol during the Years 1877 to 1889 inclusive. By William F. Denning.

There are several reasons which make it desirable to place on record the observed paths of bright meteors. Such materials enable us to determine the epochs which appear to be specially abundant in fireballs, and may also serve in the determination of their radiants. Moreover, the publication of such data is useful as a means of comparison amongst different observers, several of whom may have registered the same objects.

The following catalogue includes 217 fine meteors, chiefly as bright as *Jupiter* or *Venus*. The radiant points affixed may be generally relied upon, but it is necessary to say that in some cases there is uncertainty, notwithstanding strong presumptive evidence afforded by the flight-directions and appearance of the meteors, that they diverged from the centres assigned.

This catalogue is supplementary to the " List of observed Courses of 71 Bright Shooting Stars seen at Bristol during the Period from November 1872 to March 1876 " (*Monthly Notices*, vol. xxxvi. pp. 285–9), and to the " List of observed Paths of 85 Bright Shooting Stars recorded during the Nine Months April to December 1876 " (*Monthly Notices*, vol. xxxvii. pp. 112–5). In these lists I included all meteors equal to 1st magnitude stars, but in the present catalogue I have omitted these, owing to the very large number of such observations which I have accumulated during the last thirteen years. To have given them would have swelled the catalogue to an immoderate length.

Catalogue of 217 Bright Meteors observed at Bristol during the years 1877 to 1889.

(Continued from Monthly Notices, vol. xxxvii. p. 115, January 1877.)

Date	G.M.T.	Mag.	Apparent Path From α δ	To α δ	Length	Radiant Point α δ	Appearance, &c.
	h m		° °	° °		° °	
1877 Jan. 4	8 51	> ♀	134 +45	169 +44	25	57 −12	Slow. Duration, 2½ sec.
14	14 44	♃	195 +68	264 +48	39	130 +44	Swift; streak 15° 3 sec.
May 30	11 26	♃*	333 +27	324 +14	15	20 +58	Slow; streak; yellow.
July 6	12 5	♃	326 +60	350 +60½	12	χ Cygni	Swift; inexact. In clouds.
Aug. 7	10 54	♃	346 +22	329 − 1	28	40 +56	Swift; streak; D. 0·7 sec.
10	10 26	♃	165 +79	198 +61	21	43 +58	Swift; streak; D. 0·5 sec.
10	11 51	♃	77 +55	96 +48	13	43 +58	Swift; streak; D. 0·3 sec.
10	12 57	> ♀	69 +35	76 +25	12	43 +58	Swift; streak 30 sec.; D. 0·3 sec.
10	14 4	♃	96 +43	106 +35	11	43 +58	Swift; streak; 3° for 20 sec.
10	14 30	♃	53 +35	56 +25	11	43 +58	Swift; streak 25 sec.; D. 0·4 sec.
Sep. 15	12 21	♃	56 ± 0	55 − 6	6	61 +36	Swift; streak 4 sec.
15	15 30	♃	139 +78	282 +87	15	130 +46	Swift; streak.
16	14 42	♃	73 + 5	60 − 5	16	88 +17	Swift; streak.
Oct. 2	8 59	♀	325 +67	354 +48	24	225 +52	Slow; streak 3½ minutes; D. 1·5 sec.
2	9 47	♃	203 +40	198 +36		225 +52	Slow; D. 1 sec.
3	8 38	♀	155 +64	152 +55	10	160 +78	Swift; streak 2° for 15 sec.
7	9 14	♃	310 +60	319 +55½	6¼	299 +64	Slow; streak; D. 0·7 sec.
8	11 50	♃ ♀	109 +17	116 +12	8	77 +32	Very, very swift; streak 4° 2 sec.: D. 0·2 sec.

Date.	G. M. T.	Mag.	Apparent Path. From α δ	To α δ	Length.	Radiant Point. α δ	Appearance, &c.
1877 Oct. 8	13 35	♃	46 +50	346 +32	47	108+38	Slowish; streak 25°; D. 1·3 sec.
15	16 25	♃	222 +83	263 +76	10½	133+79	Very swift; streak 3°; D. 0·2 sec.
16	13 18	♃	105 +39	116 +50	13	92+15	Very swift; streak 5° 3 sec.; D. 0·2 sec.
17	16 29	♃	150 +54	186 +56	20	92+15	Very swift; streak; D. 0·3 sec.
18	16 38	♃	26 +43	1 +41	19	92+15	Very, very swift; streak; D. 0·2 sec.
Nov. 1	8 58	♃	44 +56	245 +51	68	43+22	Slow; yellow; train; D. 3·5 sec.
4	8 7	♃	31 +41	59 +69	32	20+ 8	Slow; star-like; D. 3·5 sec.
4	12 56	♃	55 +22	61 +22	5	43+22	Very slow; streak; D. 2 sec.
Dec. 2	8 20	⅓=☽	334 -11	322 -18¾	13	350- 1	Very slow; 4 bright flashes; D. 3·5 sec.
1878 June 7	9 50	⅓-☽*	220 -18	151 +15	76	247-25	Slow; D. 5 sec.
July 21	12 6	<♀	229 +72	212 +34	38	20+51	Swift; streak 25°; D. 0·5 sec.
21	12 35	<♀	219 +41	209 +33	11	242+51	Not swift; streak; D. 0·4 sec.
27	11 43	♃	32 +22	37 +14	10	11+48	Very slow, on horizon; D. 1 sec.
27	11 45	♃	348 +54	321 +47	19	32+53	Swift; streak 11°; D. 0·5 sec.
30	13 44	♀	330 -22	332 -27	6	325-12	Swift; streak 4 sec.; D. 0·3 sec.
Aug. 2	11 25	♃	356 - 9	353 -12	8	32+53	Swift; streak; D. 0·3 sec.
8	13 48	♃	65 +65	79 +67	6	44+59	Swift; streak; D. 0·4 sec.
10	9 39	♃	321 -10	312 -23	16	44+59	Swift; streak; D. 0·3 sec.
10	10 46	♃	352 +31	340½+13¼	20	44+59	Not swift; streak 20 sec.; D. 0·8 sec.

* Observed also at other stations.

Date.	G. M. T.	Mag.	Apparent Path. From α δ	To α δ	Length.	Radiant Point. α δ	Appearance, &c.
	h m		° °	° °		° °	
1878 Aug. 10	10 58	♃	41 +22	41 +15	7	44+59	Swift; flash; streak 2°; D. 0'3 sec.
Aug. 10	11 50	♃	354 +66	326 +60	14	44+59	Swift; streak 10°; D. 0'4 sec.
Sep. 1	10 20	<♀	161 +70	155 +56	14	315+76	Swift; streak; D. 0'4 sec.
8	8 35	>♀	246 +21	244½+ 5	16	61+36	Swift; streak 4° 20 sec.; D. 0'4 sec.
25	15 5	♃	66 + 8	61½- 3	12	87+42	Very swift; streak 7°; D. 0'2 sec.
Nov. 18	9 50	♃*	47 -26½	50 -27½	3	354+ 1	Slow; only end seen.
Dec. 21	9 33	♀	13 - 5	11 -19	14	? Ursa	Very swift; streak 1° 7 sec.; D. 0'3 sec.
1879 July 29	12 16	♃	140 +66	158 +54	15	32+53	Swift; bright streak.
Aug. 9	11 52	♃	34 +78	254 +85½	15	46+58	Swift; streak.
12	11 30	♃	6 +47	351 +37	15	46+58	Swift; streak.
22	14 50	<♃	326 +30	325¾+22	8	330+69	Slow.
23	9 18	>♃	340 +53	360 +43¾	16	291+60	Slow; train.
23	10 7	♃	341 +33	347 +23	11	291+60	Slow; bright streak 5 sec.
25	9 57	♀	79 +76	89 +67	9	291+60	Slowish; bright flash and train.
25	12 2	♃	334 +59	314 +58½	11	24+41	Swift; streak.
Sep. 15	9 1	♀	196 +77	267 +54	34	125+46	Very, very swift; streak; bright flash.
21	13 30	♃	112 +58	127 +63	9	87+42	Swift; streak; bright flash.
21	14 36	♀	28 -19	37 -27	11½	339+32	Slow; streak; 2 flashes.
25	13 36	♀	48 -16	58 -22	11	339+32	Streak; 2 flashes.
25	14 39	>♃	116 +36	128½+28	13	98+42	Swift; streak.

Date	G. M. T.	Mag.	Apparent Path From α δ	To α δ	Length.	Radiant Point. α δ	Appearance, &c.
	h m		° °	° °		° °	
1879 Oct. 14	15 41	♃	116 +18	117½+ 4	14	114+62	Swift; streak.
14	16 45	♀	123 +63	147 +70	12	93+17	Very swift; bright streak.
15	9 8	♃	98 +76	113 +80	5	78+57	Slow; bright streak; 4 sec.
15	16 19	♃	151 +41	178 +43	20	106+23	Swift; streak.
16	7 39	♃	19 +59	348 +36	30	105+50	Swift; bright streak.
20	7 39	♃	336 +22½	293 +15½	41	31+18	Slow; bright streak.
20	12 15	♃	89 +57	69 +84	27	93+17	Very swift; streak.
Nov. 10	7 20	♀	213 +56	207 +32	25	7+51	Slowish.
13	15 6	♃	98 +37	77 +36	17	148+23	Very swift; streak.
13	16 41	♃	184 +30	193 +30	7½	148+23	Very swift; streak.
1880 Jan. 2	6 16	♃	253 +44	261 +38	8	228+54	Slow; flash.
2	7 50	>♃	138 +41	126 +29	15	228+54	Slow; bright train.
2	9 8	>♃	32 +60	353 +56	20	Auriga	Slow; bright train.
Mar. 29	7 57	>♃	247 +42	200 ± 0	59	297+52(?)	Very, very slow; D. 7 or 8 sec.
Apr. 4	10 5	>♃*	293 +69	246 +53	27	27+18	Slow; thick train.
May 27	11 10	♃	327 +30	357 +34	26	Ophiuchus	Slow; starlike.
July 29	10 44	>♃	22 +86	55 +76	11	257+64	Swift; in haze near *Polaris.*
Aug. 7	12 25	♀	55 +53	64 +50	6	41+55	Bright streak.

* Observed also at other stations.

Date.	G. M. T.	Mag.	Apparent Path From α δ	To α δ	Length.	Radiant Point. α δ	Appearance, &c.
1880 Aug. 8	12 49	> 24	28 +44	24 +39¾	5	41+55	Bright streak; 2 max.
8	13 37	¼ = ☽	266½ + 7	264½ - 2	5	41+55	Very swift; streak; bright flash.
9	12 23	> ♀	332 + 7	320 - 10	20	44+55	Streak, bright flash.
9	12 40	24	122 +73	158 +66⅓	14	44+55	Streak.
10	10 29	24	316 +81	259 +67	19	45+57	Streak for 6 sec.
10	11 11	24	327 +55	302 +37	24	45+57	Streak for 4 sec.
11	9 20	24	291 +12	292 - 3	15	Ursa or Lynx	Swift; streak.
Sep. 6	10 35	24	294 + 7½	999 - 8	21	61+36	Very swift; streak.
Oct. 11	10 24	24	250 +39	251 +28	11	77+33	Streak for 20 sec.
23	...	> 24	8 + 1	353 - 7	17	Aries-Taurus	Streak.
29	9 50	> ♀*	38 +18	26 +22	12	46+15	Streak; several flashes.
30	7 24	24	337 +36	343 + 8	28	190+70	Streak for 7 sec.
Nov. 17	7 47	> 24	344 - 1	321 -14	26	61+35	Streak for 4 sec.
27	9 2	> 24	57 +67	38 +82	15½	63+21	Streak ¼°; bright flash.
1881 July 24	8 53	24	108 +69	91 +55	15	242+51	Very slow.
24	13 59	♀	336 - 5	340⅞ - 4	4⅔	318 - 9	Streak; vivid flash.
27	12 2	24	334 +71	282 +61	22	32+56	Swift; streak.
31	10 57	24	12 +54	17 +59	6	{8+48 or Pegasus}	Slowish; streak 5°.
Aug. 2	10 49	24	359 +58	341 +56	10	39+55	Swift; streak 4 sec.

Date		G.M.T.	Mag.	Apparent Path		Length	Radiant Point	Appearance, &c.
				From ° °	To ° °		° °	
		h m						
1881	Aug. 2	12 0	< ♃	26⅓ +44	24 +37	7	39+55	Swift; streak.
	12	11 43	♃	50 +66	93 +65	18	8+50	Rather swift; streak.
	21	8 50	> ♀	200 +48	178 +29	25	291+60	Slowish.
	27	12 0	> ♃	26 +68⅓	64 +68	14	331+37	Slow; sparks.
1882	Aug. 6	10 35	♃	328 +70	297 +62	15	42+57	Swift; streak.
	Nov. 6	16 36	♃	146 +41	183 +18	39	{61+35, 43+22}	Slowish; bright spark train.
1883	July 28	10 36	♃	23 +44	22 +40	4	27+55	Slow; streak 3 sec.
	28	11 10	♀	320 +11	305 −13	28	27+55	Swift; streak 20 sec.
	28	13 37	♃	351 +5	357 +11	9	337−11	Slow.
	Oct. 17	9 33	♀	259 +48⅓	241⅔+24	28	40+20	Slow; 3 flashes; streak 4 sec.
	26	9 17	½=☽	288 +56	333 +59	24	254+37	Streak; 4 flashes.
	Dec. 6	12 17	♃	348 +32	334½+27⅔	12	80+23	Slow; streak 10 sec.
1884	Jan. 6	5 33	♃	298 +32	303 +13	19	290+52	Slow.
	July 25	13 0	♃	341 +34	337 +27⅔	11	48+43½	Swift; streak; flash.
	Aug. 16	9 52	♃	52 +63	51 +67	4	53+58	Slow; bright streak.
	23	10 46	♃	45 +19	23 +29	15	41+15	Slow; dense streak.
	23	13 21	♃	40⅓+53	80 +88	35	41+15	Swift; dense streak.
	26	11 4	♃	350 +28⅓	312 +23⅓	34	46+18	Swift; streak.
	Nov. 21	10 10	♃	137 +51	160 +48⅓	15	62+22	Swift; flash inexact.

* Observed also at other stations.

Date.	G.M.T.	Mag.	Apparent Path. From	Apparent Path. To	Length.	Radiant Point. α δ	Appearance, &c.
	h m		α δ	α δ			
1885 Apr. 18	12 57	♃	215 − 4	203 − 17	18	260 + 33½	Not swift; bright flash and streak.
20	13 14	♃	207⅔ + 3¼	194 − 5⅔	16	274 + 33½	Very swift; flash and streak.
20	14 1	♃	214 − 10	208 − 15½	8	274 + 33⅔	Very swift; flash.
July 8	12 1	♃	240 + 61	218 + 37	27	11 + 48	Very swift; bright streak.
8	12 10	♃	297 + 69	301 + 71	2½	290 + 60	Very slow; thick train.
9	13 45	♃	300 + 9	298¾ + 22	13½	304 − 15	Rather slow.
Aug. 8	12 54	♃	7 + 43½	353 + 31	17	43 + 57	Swift; streak.
15	11 44	♃	297 + 73½	268 + 57	19	48 + 57	Swift; bright streak.
17	10 59	♃	346 + 59	318 + 46	21	55 + 56	Swift; streak.
Sep. 9	15 48	♃	149 + 82	152 + 64	18	335 + 71	Not very swift; streak.
15	15 11	♃	37 + 6½	26½ + 7	10½	70 + 4	Swift; bright streak 10 sec.
Oct. 7	10 51	♃	51⅔ + 22	71½ + 24	18	31 + 18	Slow; train.
8	15 9	♃	155 + 53	162⅔ + 46½	8	42 + 55	Swift; bright streak and flash.
12	14 26	♀	119 + 51	151 + 60⅔	20	88 + 18	Swift; bright streak.
12	14 26	♃	119½ + 50	143 + 60½	16½	103 + 33	Swift; bright streak.
16	16 35	♃	213 + 47½	226 + 41	11	143 + 49	Swift; streak; disc.
Nov. 15	14 18	♃	197 + 62	212 + 47	17	60 + 28	Slow; 3 max.
26	8 42	♃	48 + 40	61 + 36	11	26 + 44	Very slow; train.
26	10 9	♃	158 + 73½	177 + 60½	14½	26 + 44	Thick train; flash.
27	5 22	♀	62 + 52	85 + 50½	14½	24 + 44	Slow; train.

Date	G.M.T.	Mag.	Apparent Path From (α δ)	To (α δ)	Length	Radiant Point (α δ)	Appearance, &c.
	h m		° °	° °		° °	
1885 Nov. 27	5 29	♀	20 +25	18½+13	12	24+44	Slow; train.
Dec. 9	16 30	♃	35 +56	38½+38	17	27+71	Slow; streaky train.
1886 Jan. 2	7 8	♀	225 +47	224 +44	3	228+52	Very slow; 3 outbursts.
4	11 14	♀	164 +58	215 +52	29	133+49 (?)	Slow; halting; 3 max.
June 4	12 35	♃	331 +31½	329 +39	7½	333+27	Very slow; 2 max.; bright streak.
July 21	10 53	♃	349 + 9	346½+ 1	8½	20+58	Swift; streak; flash.
Aug. 4	10 40	♃*	129 +60	83 +40	34	162+59	Very, very slow; D. 8 sec.
6	10 3	♃	352 +13	320 + 3	32	{31+18, 42+20}	Slow; bright streak.
10	9 53	♃	42 +72	49 +84	12	44+57	Slow; broken streak.
10	13 34	>♀*	77 +67	111 +67	13	44+57	Swift; streak 3½ min.; flash.
Sep. 7	13 39	♀	146 +78	205 +74	15	8 Aurigae	Very swift; streak; 2 max.
22	10 26	♃	50 +20	42 +18	7½	63+23	Slowish; bright streak.
27	15 21	♃	16 +46	17½+61	15	14+12	Slowish; train.
Oct. 23	9 40	♃	116 +59	155 +49	24½	31+19	Very slow; flash at end.
Nov. 2	11 48	♃	21 +52	2½+45	14	97+42	Very swift; streak.
3	11 49	♃	20 +23½	10 +19	10½	60+34	Not swift; train; flash.
17	7 18	>♀*	32½+45	158 +55	63	34+19	Very slow; train; D. 7 sec.
Dec. 4	9 17	♀*	184 +52½	195 +47	9½	162+58	Rather swift; streak 1½ min.
5	15 20	♃	182½+34½	191 +31½	8	155+40	Very swift.
18	11 14	♀	194 +58	193½+53	5	195+68	Not swift.

* Observed also at other stations

Date.	G.M.T.	Mag.	Apparent Path. From	To	Length.	Radiant Point. α δ	Appearance, &c.
	h m		° °	° °		° °	
1887 Jan. 20	6 48	♃	146 +36	168 +35	18	116+30 (?)	Very, very slow; D. 5 sec.
Feb. 2	15 44	♃	68 +84	60 +68	16	θ Draconis (?)	Not very swift.
Mar. 28	12 53	♃	333 +50	345½+40	13¼	263+62	Rather swift.
Apr. 19	13 13	♀	269 +11	269 + 1	10	269+31	Swift; streak.
19	13 46	♃	308 +61½	56 +65½	42	280−14	Swift; streak.
June 14	13 5	♀	349½+68	300 +87½	20	353+38	Very swift; streak 5 sec.
23	9 47	♃	311 + 9	346 +15	35	Serpens-Libra	Very slow.
23	11 54	♃	173 +55	148 +53	15	252+11	Very slow.
25	12 54	♃	38 +48	39 +42½	5¾	40+56 (?)	Slow; bright streak 5 sec.
July 22	10 59	♃	16 +41	16½+51	10	16+31	Slow; very bright streak.
22	12 21	♃	356+45	332 +29	24½	25+52	Swift; bright streak.
22	12 25	♃	344 +33	320 +29	20½	16+31	Swift; bright streak.
22	13 15½	♃	323 +37	355½+10½	39	271+48	Not swift.
27	10 40½	♃	325 + 6	330 + 8	5	322+ 4	Very slow; streak 4 sec.
27	13 21	♃	319½+16½	308 +32	19	337−12	Not swift; streaky train.
29	11 28	♃	66 +72½	114 +70	15½	20+57	Swift; streak.
Aug. 1	12 18½	♀	338 +43	164 +70	67	337−12	Slowish; streak 5 sec.
6	11 29	♃	25 +86½	213 +72	22	31+49	Swift; streak.
7	11 49	♃	79 +39	92 +34	11	333+12	Slow; starlike.
8	10 34	♃	6 +67½	302 +60½	27	43+56	Swift; streak.
8	11 28	♀	349 +15	9 +14¼	20	304+11	Rather swift.
11	10 51	♃	31 +45	26 +37½	8	45+57	Swift; streak.

Date	G.M.T.	Mag.	Apparent Path		Length	Radiant Point	Appearance, &c.
			From	To			
	h m		° δ	° δ		° δ	
1887 Aug. 14	13 53	♃	20 +35	6 +14	24	53+57	Swift; streak.
20	11 22½	♃	60 +54	41 +65	14¾	73+41	Rather swift; bright streak.
21	11 2	♀*	230 +61	218 +59	6	262+61½	Slow; bright streak.
25	11 9	♃	328 +22	326½+ 3	19	334+58	Rather swift; streak or train.
30	14 25	♀	19 +27	5 +14	18½	46+43	Swift; bright streak.
Sep. 17	10 37	♃	51 +18	66 +24¾	15¼	31+ 8	Slow; train.
17	13 26	♃	45½+34	19 +52	26	64+11	Swift; bright streak.
18	12 14	♃	337 +63	238 +63	29	41+38	Swift; bright streak.
22	9 19	♀*	43 +19½	50 +19¼	7	248–18	Not swift.
24	11 56	♃	235 +80	47 +10	89	230+52	Very, very slow.
24	11 57	♃	107 +50	125 +49	12	34+19½	Swift; streak.
Oct. 11	8 32¾	♃	183½+55	184 +43	12	13+ 6	Very slow.
11	8 57½	♀	260 +20	243 +25½	16	13+ 6 (?)	Slow.
14	9 33	♃	27½+ 1	57 – 1	29½	346± 0	Very, very slow; D. 6 sec.
14	10 54	♃	123 +70	100 +70½	7¾	133+69	Slow; bright streak.
17	11 58½	♀	72 +11	53 + 5½	19	90+15	Swift; streak.
19	6 20	♃	1 +34	305 +56½	43	22+ 8	Very slow; train.
21	15 3	♃	89 +13½	78½– 2	25	132+32	Swift; streak.
Nov. 1	8 35	♃	269½+10	268 + 2	8	Auriga	Swift.
23	17 52½	♃	132 +67	96 +84	19	141+27	Very swift; streak.
1888 Jan. 2	10 58	♃*	261 +61½	278 +64	8	250+57	Very slow.
Avg. 2	11 19	♃	346½+ 0½	341 –11½	12	35+54	Very swift; streak.

* Observed at other stations.

Date.	G.M.T.	Mag.	Apparent Path.		Length.	Radiant Point.	Appearance, &c.
	h m		From α δ	To α δ		α δ	
1888 Aug. 2	13 10	♃	351¼ +22	346 +14	9½	35 +54	Swift; streak.
5	11 17	♃	335½ +30	325 +18	15	42 +57	Swift; streak.
8	12 3	♀	302 +56	320 +55¼	10½	{ 291 +51 or Lyra }	Very slow; bright train.
9	12 22	♃	65½ +32	69½ +27	6	Perseid	Swift; streak.
13	11 33	♀*	113 +57½	126 +52½	9	43 +57	Swift; streak.
26	8 17	♀*	108½ +55	107½ +46	11	278 +52½	Swift.
30	10 30	♃	222 +71	219 +68	3	225 +74	Very slow; bright train.
Sep. 6	13 9	♀	355½ +29	354½ +40	11	0 − 3 (?)	Swift.
7	11 56	♀	128 +54	127½ +45	9	Polaris (?)	Streak.
7	12 23	♀	341 +40½	8 +34	22	271 +22 (?)	Very slow.
Oct. 30	9 56	♃	82 +15	94 + 9½	14	Taurid	Very slow.
Nov. 13	16 41	♃	166 +34	172 +37¼	6	149 +22	Swift; bright streak.
13	16 55	>♀	125½ −22	121 −30½	9½	149 +22	Swift; bright streak.
13	17 19	♃*	252 +33½	257½ +31	5¼	149 +22	Swift; bright streak.
Dec. 28	9 4	♃	201 +69	158 +76½	15	226 +47	Very slow; streak 5 sec.
1889 Jan. 29	11 54	♃	156 +16	145 +17½	11	176 +12	Swift; not well seen.
Apr. 27	8 51	♀*	218 +49½	249 +32½	29	121 +28	Very slow; several max.
May 22†	10 8	>1*	287 +39	254½ −15	62	63 +35	Very, very slow; D. 16 secs.(!); bright train.
July 26	11 30	♃	349 +15½	320 + 6	30	42 +20	Not very swift; streak.
Sep. 25†	8 5	1*	332 − 7½	11 + 8	42	269 −22	Very, very slow; D. 13 secs. (!); bright train.

* Observed also at other stations.

† These meteors are included owing to their exceptionally long duration.

Ephemeris for Physical Observations of the Moon.   By A. Marth.
1890, *January* 1 *to July* 1.

Greenwich Noon.	Selenographical Colong. | Lat. of the Sun.		Geocentric Libration. Sel. Long. | Lat. of the Earth.		Amount	Direction.
1890. Jan. 1	32·45	−0·22	+6·06	+4·71	7·67	308·0
2	44·59	·25	5·03	3·56	6·16	305·4
3	56·72	·28	3·83	2·27	4·45	300·7
4	68·85	·31	2·51	+0·89	2·66	289·6
5	80·98	−0·34	+1·13	−0·52	1·24	265·2
6	93·11	·37	−0·28	1·90	1·92	171·6
7	105·24	·41	1·67	3·21	3·61	152·5
8	117·37	·44	3·01	4·37	5·30	145·6
9	129·50	·47	4·25	5·36	6·83	141·7
10	141·64	·50	5·36	6·11	8·12	138·9
11	153·78	·53	6·29	6·60	9·11	136·6
12	165·92	−0·55	−7·00	−6·80	9·74	134·4
13	178·07	·58	7·43	6·66	9·97	132·1
14	190·23	·60	7·54	6·19	9·74	129·6
15	202·40	·63	7·28	5·37	9·03	126·6
16	214·57	·65	6·62	4·21	7·84	122·6
17	226·75	·67	5·56	2·76	6·21	116·5
18	238·93	·70	4·11	−1·10	4·26	105·0
19	251·12	−0·72	−2·35	+0·67	2·44	74·0
20	263·31	·74	−0·37	2·40	2·43	8·8
21	275·50	·76	+1·66	4·00	4·33	337·4
22	287·70	·78	3·60	5·28	6·39	325·8
23	299·89	·80	5·27	6·18	8·12	319·7
24	312·07	·83	6·56	6·66	9·34	315·6
25	324·25	·85	7·39	6·73	9·98	312·5
26	336·43	−0·87	+7·73	+6·41	10·03	309·9
27	348·60	·90	7·60	5·77	9·53	307·4
28	0·76	·92	7·06	4·86	8·56	304·7
29	12·91	·95	6·17	3·75	7·22	301·4
30	25·06	0·97	5·03	2·50	5·62	296·4
31	37·21	1·00	3·72	+1·15	3·89	287·1
Feb. 1	49·35	1·02	2·32	−0·24	2·33	264·1

Greenwich Noon.	Selenographical Colong.	Lat. of the Sun.	Geocentric Libration. Sel. Long.	Lat. of the Earth.	Amount.	Direction.
1890.	°	°	°	°	°	°
Feb. 2	61·49	− 1·05	+ 0·89	− 1·61	1·83	208·7
3	73·63	1·07	− 0·51	2·91	2·95	170·0
4	85·76	1·09	1·83	4·09	4·48	156·0
5	97·89	1·12	3·03	5·10	5·93	149·3
6	110·03	1·14	4·09	5·89	7·17	145·3
7	122·16	1·16	5·00	6·42	8·13	142·2
8	134·30	1·18	5·73	6·65	8·77	139·4
9	146·44	− 1·20	− 6·27	− 6·57	9·07	136·5
10	158·59	1·22	6·61	6·16	9·02	133·2
11	170·75	1·23	6·71	5·42	8·62	129·1
12	182·91	1·24	6·54	4·38	7·87	123·9
13	195·08	1·26	6·05	3·07	6·79	117·0
14	207·26	1·27	5·29	− 1·55	5·51	106·3
15	219·44	1·28	4·17	+ 0·11	4·31	75·1
16	231·63	− 1·30	− 2·73	+ 1·79	3·27	56·7
17	243·83	1·31	− 1·05	3·38	3·54	17·2
18	256·03	1·32	+ 0·78	4·74	4·81	350·6
19	268·23	1·33	2·63	5·77	6·34	335·6
20	280·43	1·34	4·28	6·41	7·70	326·4
21	292·63	1·36	5·64	6·61	8·68	319·7
22	304·83	1·37	6·58	6·40	9·17	314·4
23	317·02	− 1·38	+ 7·03	+ 5·82	9·12	309·8
24	329·21	1·39	7·00	4·96	8·57	305·5
25	341·39	1·41	6·52	3·87	7·58	300·8
26	353·57	1·42	5·67	2·63	6·25	294·9
27	5·74	1·43	4·53	+ 1·30	4·72	286·0
28	17·91	1·45	3·21	− 0·06	3·21	269·0
Mar. 1	30·07	1·46	1·80	1·42	2·29	231·6
2	42·23	− 1·47	+ 0·38	− 2·71	2·74	187·1
3	54·38	1·48	− 0·97	3·89	4·01	166·0
4	66·53	1·49	2·19	4·90	5·37	156·0
5	78·68	1·50	3·23	5·71	6·56	150·6
6	90·82	1·51	4·08	6·26	7·47	147·1
7	102·96	1·52	4·72	6·53	8·05	144·3
8	115·11	1·52	5·15	6·47	8·27	141·6

Greenwich Noon.	Selenographical Colong. of the Sun.	Lat.	Geocentric Libration. Sel. Long. of the Earth.	Lat.	Amount.	Direction.
1890. Mar. 9	127·26	− 1·52	− 5·40	− 6·09	8·13	138·6
10	139·42	1·53	5·47	5·38	7·67	134·7
11	151·58	1·53	5·36	4·38	6·92	129·3
12	163·74	1·53	5·09	3·12	5·96	121·6
13	175·91	1·53	4·62	1·66	4·91	109·7
14	188·09	1·53	3·95	− 0·08	3·95	91·1
15	201·28	1·53	3·05	+ 1·53	3·42	63·3
16	212·48	− 1·53	− 1·94	+ 3·07	3·63	32·2
17	224·68	1·53	− 0·63	4·43	4·47	8·1
18	236·89	1·53	+ 0·81	5·50	5·56	351·7
19	249·10	1·52	2·27	6·22	6·62	340·0
20	261·31	1·52	3·64	6·53	7·47	331·0
21	273·53	1·52	4·78	6·42	8·00	323·5
22	285·75	1·52	5·58	5·93	8·14	316·9
23	297·96	− 1·52	+ 5·97	+ 5·12	7·86	310·7
24	310·17	1·52	5·93	4·05	7·18	304·4
25	322·38	1·52	5·48	2·80	6·15	297·2
26	334·58	1·52	4·66	1·46	4·88	287·4
27	346·78	1·52	3·56	+ 0·07	3·56	271·2
28	359 97	1·52	2·27	− 1·29	2·59	241·5
29	12·15	1·51	+ 0·89	2·59	2·74	198·9
30	23·33	− 1·51	− 0·51	− 3·76	3·79	172·3
31	35·51	1·51	1·78	4·81	5·13	159·7
Apr. 1	47·68	1·50	2·91	5·64	6·35	152·8
2	59·85	1·50	3·82	6·22	7·30	148·6
3	72·01	1·49	4·47	6·53	7·91	145·7
4	84·17	1·48	4·85	6·51	8·11	143·4
5	96·33	1·47	4·98	6·16	7·91	141·2
6	108·49	− 1·46	− 4·87	− 5·47	7·32	138·5
7	120·66	1·45	4·56	4·47	6·39	134·5
8	132·83	1·44	4·10	3·20	5·21	128·0
9	145·00	1·42	3·52	1·73	3·92	116·2
10	157·18	1·41	2·83	− 0·14	2·83	92·9
11	169·37	1·40	2·04	+ 1·47	2·51	54·7
12	171·56	1·38	1·15	3·00	3·21	21·0

Greenwich Noon.	Selenographical Colong. | Lat. of the Sun.		Geocentric Libration. Sel. Long. | Lat. of the Earth.		Amount.	Direction.
1890. Feb. 2	61·49	− 1·05	+ 0·89	− 1·61	1·83	208·7
3	73·63	1·07	− 0·51	2·91	2·95	170·0
4	85·76	1·09	1·83	4·09	4·48	156·0
5	97·89	1·12	3·03	5·10	5·93	149·3
6	110·03	1·14	4·09	5·89	7·17	145·3
7	122·16	1·16	5·00	6·42	8·13	142·2
8	134·30	1·18	5·73	6·65	8·77	139·4
9	146·44	− 1·20	− 6·27	− 6·57	9·07	136·5
10	158·59	1·22	6·61	6·16	9·02	133·2
11	170·75	1·23	6·71	5·42	8·62	129·1
12	182·91	1·24	6·54	4·38	7·87	123·9
13	195·08	1·26	6·05	3·07	6·79	117·0
14	207·26	1·27	5·29	− 1·55	5·51	106·3
15	219·44	1·28	4·17	+ 0·11	4·31	75·1
16	231·63	− 1·30	− 2·73	+ 1·79	3·27	56·7
17	243·83	1·31	− 1·05	3·38	3·54	17·2
18	256·03	1·32	+ 0·78	4·74	4·81	350·6
19	268·23	1·33	2·63	5·77	6·34	335·6
20	280·43	1·34	4·28	6·41	7·70	326·4
21	292·63	1·36	5·64	6·61	8·68	319·7
22	304·83	1·37	6·58	6·40	9·17	314·4
23	317·02	− 1·38	+ 7·03	+ 5·82	9·12	309·8
24	329·21	1·39	7·00	4·96	8·57	305·5
25	341·39	1·41	6·52	3·87	7·58	300·8
26	353·57	1·42	5·67	2·63	6·25	294·9
27	5·74	1·43	4·53	+ 1·30	4·72	286·0
28	17·91	1·45	3·21	− 0·06	3·21	269·0
Mar. 1	30·07	1·46	1·80	1·42	2·29	231·6
2	42·23	− 1·47	+ 0·38	− 2·71	2·74	187·1
3	54·38	1·48	− 0·97	3·89	4·01	166·0
4	66·53	1·49	2·19	4·90	5·37	156·0
5	78·68	1·50	3·23	5·71	6·56	150·6
6	90·82	1·51	4·08	6·26	7·47	147·1
7	102·96	1·52	4·72	6·53	8·05	144·3
8	115·11	1·52	5·15	6·47	8·27	141·6

Greenwich Noon.	Selenographical Colong. | Lat. of the Sun.		Geocentric Libration. Sel. Long. | Lat. of the Earth.		Amount.	Direction.
1890. Mar. 9	127·26	− 1·52	− 5·40	− 6·09	8·13	138·6
10	139·42	1·53	5·47	5·38	7·67	134·7
11	151·58	1·53	5·36	4·38	6·92	129·3
12	163·74	1·53	5·09	3·12	5·96	121·6
13	175·91	1·53	4·62	1·66	4·91	109·7
14	188·09	1·53	3·95	− 0·08	3·95	91·1
15	201·28	1·53	3·05	+ 1·53	3·42	63·3
16	212·48	− 1·53	− 1·94	+ 3·07	3·63	32·2
17	224·68	1·53	− 0·63	4·43	4·47	8·1
18	236·89	1·53	+ 0·81	5·50	5·56	351·7
19	249·10	1·52	2·27	6·22	6·62	340·0
20	261·31	1·52	3·64	6·53	7·47	331·0
21	273·53	1·52	4·78	6·42	8·00	323·5
22	285·75	1·52	5·58	5·93	8·14	316·9
23	297·96	− 1·52	+ 5·97	+ 5·12	7·86	310·7
24	310·17	1·52	5·93	4·05	7·18	304·4
25	322·38	1·52	5·48	2·80	6·15	297·2
26	334·58	1·52	4·66	1·46	4·88	287·4
27	346·78	1·52	3·56	+ 0·07	3·56	271·2
28	359 97	1·52	2·27	− 1·29	2·59	241·5
29	12·15	1·51	+ 0·89	2·59	2·74	198·9
30	23·33	− 1·51	− 0·51	− 3·76	3·79	172·3
31	35·51	1·51	1·78	4·81	5·13	159·7
Apr. 1	47·68	1·50	2·91	5·64	6·35	152·8
2	59·85	1·50	3·82	6·22	7·30	148·6
3	72·01	1·49	4·47	6·53	7·91	145·7
4	84·17	1·48	4·85	6·51	8·11	143·4
5	96·33	1·47	4·98	6·16	7·91	141·2
6	108·49	− 1·46	− 4·87	− 5·47	7·32	138·5
7	120·66	1·45	4·56	4·47	6·39	134·5
8	132·83	1·44	4·10	3·20	5·21	128·0
9	145·00	1·42	3·52	1·73	3·92	116·2
10	157·18	1·41	2·83	− 0·14	2·83	92·9
11	169·37	1·4C	2·04	+ 1·47	2·51	54·7
12	171·56	1·38	1·15	3·00	3·21	21·0

Greenwich Noon.	Selenographical Colong.	Lat. of the Sun.	Geocentric Libration. Sel. Long.	Lat. of the Earth.	Amount.	Direction.
1890.	°	°	°	°	°	°
Apr. 13	193·76	− 1·37	− 0·19	+ 4·36	4·37	2·5
14	205·97	1·35	+ 0·84	5·44	5·51	351·2
15	218·19	1·34	1·90	6·20	6·48	343·0
16	230·41	1·32	2·93	6·57	7·19	336·1
17	242·63	1·31	3·84	6·55	7·59	329·7
18	254·86	1·30	4·56	6·13	7·64	323·5
19	267·09	1·28	5·01	5·38	7·35	317·1
20	279·33	− 1·27	+ 5·14	+ 4·34	6·73	310·2
21	291·56	1·26	4·93	3·10	5·82	302·2
22	303·79	1·25	4·37	1·73	4·70	291·6
23	316·01	1·23	3·51	+ 0·31	3·53	275·1
24	328·23	1·22	2·41	− 1·10	2·65	245·5
25	340·45	1·21	+ 1·14	2·44	2·69	205·1
26	352·66	1·19	− 0·21	3·67	3·68	176·7
27	4·86	− 1·18	− 1·56	− 4·74	4·99	161·8
28	17·06	1·16	2·81	5·61	6·28	153·4
29	29·26	1·14	3·89	6·25	7·36	148·2
30	41·45	1·12	4·73	6·61	8·12	144·6
May 1	53·63	1·10	5·27	6·66	8·49	141·8
2	65·81	1·08	5·49	6·38	8·41	139·5
3	77·99	1·06	5·38	5·76	7·88	137·1
4	90·17	− 1·04	− 4·97	− 4·80	6·90	134·1
5	102·35	1·01	4·30	3·54	5·56	129·5
6	114·53	0·99	3·42	2·04	3·99	120·8
7	126·71	·97	2·42	− 0·40	2·45	99·4
8	138·89	·94	1·33	+ 1·28	1·84	46·2
9	151·08	·92	− 0·23	2·88	2·88	4·5
10	163·28	·89	+ 0·86	4·29	4·38	348·7
11	175·49	− 0·87	+ 1·89	+ 5·44	5·76	340·9
12	187·70	·84	2·84	6·25	6·86	335·7
13	199·92	·82	3·66	6·67	7·61	331·4
14	212·15	·80	4·33	6·71	7·98	327·3
15	224·38	·77	4·82	6·36	7·98	323·0
16	236·62	·75	5·09	5·67	7·61	318·3
17	248·86	·73	5·10	4·69	6·93	312·7

Greenwich Noon.	Selenographical Colong.	Lat. of the Sun.	Sel. Long.	Lat. of the Earth.	Amount.	Direction.
1890. May 18	261·11	−0·71	+4·86	+3·48	5·97	305·6
19	273·35	·69	4·35	2·11	4·84	295·9
20	285·59	·67	3·59	+0·67	3·65	280·6
21	297·84	·65	2·60	−0·78	· 2·72	253·7
22	310·08	·62	1·44	2·17	2·60	213·5
23	322·32	·60	+0·15	3·45	3·46	182·5
24	334·55	·58	−1·20	4·56	4·70	166·2
25	346·77	−0·56	−2·53	−5·52	6·07	155·4
26	358·99	·53	3·77	6·22	7·27	148·9
27	11·21	·51	4·85	6·66	8·23	144·1
28	23·42	·48	5·69	6·80	8·86	140·3
29	35·62	·46	6·22	6·62	9·08	137·0
30	47·82	·43	6·40	6·11	8·84	133·8
31	60·02	·40	6·20	5·25	8·12	130·4
June 1	72·41	−0·37	−5·63	−4·07	6·94	126·0
2	84·40	·34	4·71	2·61	5·39	119·1
3	96·59	·31	3·50	−0·96	3·63	105·4
4	108·77	·28	2·09	+0·78	2·23	69·5
5	120·96	·25	−0·56	2·48	2·54	12·8
6	133·16	·22	+0·97	4·02	4·13	346·5
7	145·36	·19	2·41	5·28	5·80	335·6
8	157·56	−0·16	+3·68	+6·19	7·20	329·4
9	169·78	·13	4·72	6·70	8·19	325·0
10	182·00	·10	5·48	6·81	8·74	321·3
11	194·23	·08	5·96	6·53	8·84	317·8
12	206·46	·05	6·14	5·90	8·51	314·0
13	218·70	−0·03	6·04	4·98	7·82	309·6
14	230·94	0·00	5·68	3·81	6·84	304·0
15	243·19	+0·02	+5·07	+2·49	5·65	296·1
16	255·44	·04	4·26	+1·06	4·39	284·0
17	267·69	·07	3·26	−0·39	3·28	263·1
18	279·94	·09	2·11	1·81	2·78	229·3
19	292·19	·11	+0·85	3·14	3·25	195·1
20	304·44	·14	−0·48	4·32	4·34	173·7
21	316·69	·16	1·83	5·31	5·59	161·0

Greenwich Noon.	Selenographical		Sel. Long.	Geocentric Libration.		
	Colong.	Lat. of the Sun.	of the Earth.	Lat. of the Earth.	Amount.	Direction.
1890. June 22	328°·93	+0°·19	−3°·15	−6°·07	6°·84	152°·7
23	341·16	·21	4·39	6·58	7·90	146·5
24	353·39	·24	5·47	6·81	8·70	141·4
25	5·62	·26	6·34	6·73	9·23	136·9
26	17·84	·29	6·93	6·33	9·37	132·6
27	30·05	·32	7·17	5·61	9·09	128·2
28	42·26	·35	7·03	4·56	8·37	123·1
29	54·46	+0·38	−6·47	−3·23	7·23	116·6
30	66·66	·41	5·49	−1·65	5·73	106·8
July 1	78·85	+0·44	−4·13	+0·07	4·13	89·1

Erratum in Mr. Gore's Paper on the Proper Motion of the Double Star South 503, Monthly Notices, Vol. L. No. 1.

Page 32, last line but one of the paper, *for* 0″·60 *read* 0″·65.

W. H. M. CHRISTIE, M.A., F.R.S., President, in the Chair.

Albert Fowell Austin, Luton, Bedfordshire;
Algernon Sidney Bicknell, Staplefield Place, Crawley, Sussex;
Rev. George Burgess, The Woodlands, Urmston, Manchester;
Démétrius Eginitis, D. ès Sc., Observatoire, Paris;
George Richard Farncombe, M.A., 40 Belgrave Street, Birmingham;
Vernon Edwin Knocker, Castle Hill House, Dover;
Benjamin Noble, F.S.S., Gloucester House, Newcastle-on-Tyne;
Henry William Lloyd Tanner, M.A., 29 Clive Road, Penarth, South Wales;
R. Lethbridge Tapscott, Assoc. M.Inst.C.E., F.G.S., F.R. Met. Soc., 41 Parkfield Road, Liverpool;
William Grasett Thackeray, Royal Observatory, Greenwich,
were balloted for and duly elected Fellows of the Society.

The following candidates were proposed for election, the names of the proposers from personal knowledge being appended:—

The Rev. S. B. Craig, B.A., LL.B., F.S.S., The Rectory, Moville, Londonderry (proposed by W. J. Lancaster);
James Edward Keeler, B.A., Astronomer of the Lick Observatory (proposed by E. E. Barnard).

The Photographic Apparatus of the Great Equatorial of the Lick Observatory. By Edward S. Holden, LL.D., Director of the Lick Observatory, Foreign Associate.

The Lick Observatory has just received from the makers of the great telescope the compound slide-rest, which is to carry the negative plate of the Great Equatorial. It may be of interest to state the problem which this machine is destined to solve and to briefly describe its arrangements.

Accordingly I have asked Mr. Barnard to photograph our photographic appliances (see figure), which he has kindly done.

K

The problem which was early presented to us in the use of the photographic lens of the great telescope was this :—

The tube of the telescope (and very likely the declination axis) is subject to slight flexures, and all long exposures therefore produced short irregular lines instead of round dots for the star images.   The focal length of the photographic lens is 47 feet 6·2 inches (aperture 33 inches), and one second· of arc is 0·0028 inches on the plate ($1' = 0$·166, $1° = 9$·948 inches).

So great a focal length makes a very slight *angular* displacement of the image readily visible on the plate as a considerable *linear* distortion.

Hence it was indispensable to provide some means of moving the plate by hand so as to keep the star images fairly round. The first experiments in photography were made by Mr. Burnham ·in August 1888, and the pictures of the Moon which have hitherto been made here are all by him.   During September 1888 Professor Schaeberle constructed a compound slide-rest out of wood, by means of which experiments were made which fully showed that ·the method proposed would be entirely successful with an apparatus constructed out of metal.   About the same time Mr. Common was kind enough to send me photographs of a very similar machine which he had adopted for his great reflector. (See *Monthly Notices*, R.A.S. vol. xlix. p. 297).

During January and February 1889 the final plan for our slide-rest was settled on, and it has been made by Messrs. Warner and Swasey in a highly satisfactory manner.   In a few days it will be in place, and astronomical photography can be resumed here after a long and regrettable interval of lost time.

The general principle of the machine is as follows :—The negative plate is mounted on a slide-rest E, movable in right ascension; the slide-rest E together with the negative plate is movable in declination on a second slide-rest D.   Attached to the right ascension slide-rest (E) is a guiding eyepiece G.   The observer directs this eyepiece, which has a reticle plate of glass with wires as below,
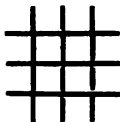
upon some selected guiding star and then makes the exposure. As long as the star remains on the proper wire of the reticle the slides are left unchanged and the negative remains in its original place.   As soon as the star leaves the wire the slides are moved by appropriate handles until the guiding star (and thus the negative) is brought back to its primitive position.

Such then is the general principle of the machine.   In the apparatus for the Lick Observatory it was necessary to introduce one more complication, namely, to give the whole machine a rotation of some 40 degrees in its own plane.   The focus of the photographic lens is 10 feet 4·2 inches nearer the object-glass than

the visual focus. Hence the photographic plate must be reached through a *port* cut in the side of the great tube. (This port is 23 by 12 inches.) The most convenient place for such a port is in the side of the tube nearest to the declination axis; but when the telescope was delivered to the astronomers I found that this port had been cut at random and without consideration in a different place, so that the negative plate when inserted would have its longest dimension inclined some 30 degrees to the parallel. Hence it was convenient to give the plate and the whole apparatus a motion of rotation of 30 degrees in its own plane.
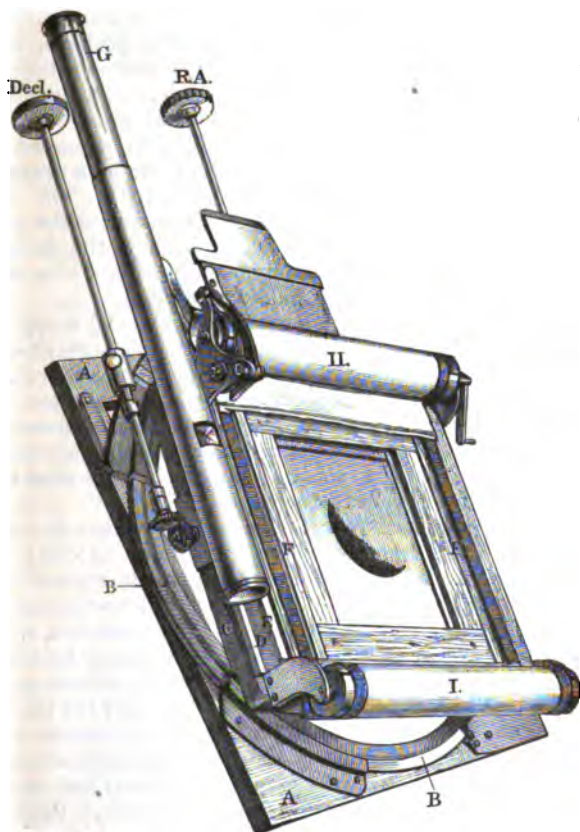
Compound Slide-Rest, for carrying the Negative Plate of the 36-inch Equatorial.

A reference to the cut will make the following description plain:—The negative of the Moon is on an 8 × 10 plate. Hence the scale of the figure is easily determined. The machine was

delivered to us beautifully lackered. It has, however, been ruthlessly painted a dull black.

The lowest square frame of the apparatus I call plate A. This is 23 × 24¾ inches, and in its centre is a square hole 19½ inches on a side. When the apparatus is put in place this plate A is supported by four rods inside the telescope tube and parallel to its axis. A motion along these rods serves to focus the plate. The system of four rods has a thwart adjustment, so that the plate can be made normal to the incident ray. Above the plate A is a circular ring, B, about 23·7 inches outside and 21·5 inside diameter. This ring is movable in its own plane through about 41 degrees by a handle which is just visible behind the guiding eyepiece. The ring can be clamped in any desired position. Rigidly fastened to ring B is a square frame C, 17½ inches outside, containing a square hole 14½ inches on a side. The declination slide, D, is 17½ inches square outside, and also has a hole 14½ inches square cut in its centre. This slide can be moved over a distance of about six or seven minutes of arc by a screw of 30 threads to the inch (1 revolution = about 10″). The smooth wooden head to the handle of this screw is seen next the guiding eyepiece. The right ascension slide E moves on the declination slide by a similar screw. The roughened handle of this screw is seen above, to the right of the guiding eyepiece.

The right ascension slide contains a hole 12¼ × 14½ inches (1° 14′ × 1° 26′), and this is the largest photographic field available, so that nothing like the whole of the nebula of *Andromeda*, for example, can be photographed at one time. This sacrifice of field was necessary. As the particular advantage of our long-focus lens is to produce negatives suitable for *measures*, this restriction of field is not so regrettable as it might be in another instrument of shorter focus.

Usually a brass box, F, rests inside of E to take the wooden plate-holders. This box has a free aperture of 14 × 12¼ inches. When the telescope is not used for photography the cone of (visual) rays passes through the centre of this hole. Two wooden plate-holders for 11 × 14 plates fit directly into the brass box, F.

A wooden carrier, of the right size to be taken by the brass box, F, and containing an 8 × 10 plate-holder is shown in place, and I have laid in it a negative of the Moon taken (in the focus) August 13, 1888. This Moon is 5·2 inches in diameter.

Above the whole machine is the exposing apparatus. This consists of two cylinders, I (the lowest in the cut) and II. They are connected by tapes along the edge of the slit. Part of the curtain is rolled on I and part on II in the cut, which shows the disposition of things for a time-exposure. The lower roller, I, contains a strong spring. If the thumb-piece on the upper roller is touched, the curtain will fly down (in the cut) and cover the aperture. For an instantaneous exposure the upper roller must be rotated (by the small crank at its end) until the lower curtain covers the aperture. The slide of the plate-holder must then be drawn. At the proper time the thumb-piece must be

touched, when the curtain will fly down, carrying the open part of the curtain past the plate, and quickly covering the plate with that portion of the curtain shown rolled up on the upper roller.

The guiding eyepiece, G, is a positive eyepiece giving a power of about 500 diameters on the photographic objective. It can be moved bodily in the direction of its length, and clamped in any position. A beam from the objective is received on the prism (near its lower end in the cut) and brought to a focus on its glass reticle, previously described. The wires of this reticle are heavy enough to be seen without illumination. If any light is needed it can be had by means of luminous paint on the reticle itself.

For enlarging, it is necessary to slip a board and tube (not shown in the cut) into the brass box, F, where the negative now is. The brass tube takes all our enlarging lenses. These are about 2 inches aperture and 14 inches focus, giving direct enlargements near the *visual* focus of 7 or 8 times. A 4 × 5 double plate-holder is used for this purpose.

It will be seen from what goes before that the process of taking a satisfactory negative with the great telescope is not a simple one. Let us suppose that a plate of the Pleiades of two hours' exposure is required. The telescope must be set, the dome turned, the driving clock wound, set in motion, and the control put on. A high step-ladder must be moved so that the observer sitting on its top can look into the guiding eyepiece. The plate is to be inserted and the slide drawn; the whole photographic slide-rest must be rotated till the parallel of declination is in the same direction as the edge of the plate, and the curtain must be withdrawn for a time-exposure, after a suitable guiding-star has been chosen. The observer sits (helpless) on the top of his high ladder, while a second observer must keep the elevating floor at the right level, see that the telescope points fairly centrally through the slit, and watch for the proper times to move the high step-ladder, so as to allow the first observer as nearly a comfortable position as is practicable. All this must be done in a dark dome, where only the feeblest red light is permissible.

Exposures longer than two hours can only be made by interruptions for winding up the clock weight (of 600 lbs.), which only runs for that period. The difficulties are considerable, and the fatigue and labour are great.

On the other hand the advantages gained are immense. Photographs of the Moon, nebulæ, stars, and planets can be had on a scale of 1 minute of arc equal $\frac{16}{100}$ of an inch. These photographs can be quickly measured on our measuring-engine with an accuracy *at least* equal to the best heliometer measures. I think there is very little doubt that a distance of 3000″ can be measured with an accidental error of not much above $\frac{1}{10}$ of a second; and hence the photographic determination of parallax should be a comparatively easy matter, provided that constant errors are avoided by taking three or four plates each night. I

have as yet had only a limited opportunity to study our nega-
tives.* I find, however, that an eyepiece of one inch equivalent
focus can be used with advantage on our best Moon negatives.
This corresponds to a magnifying power of 570 diameters. That
is, it is practicable for an observer to sit in his study and to
examine the lunar surface with a magnifying power of 570
diameters as often and as long as he pleases. Even more than
this is true. Mr. Barnard has been kind enough to make
positive enlargements on glass for me, which show the Moon
twice as large as in the principal focus. An eyepiece of one inch
equivalent focus is not too high to examine some features of
these enlargements (and as they are *positives* they show the
surface in its true light and colour). Thus it is practicable to
see the lunar surface under excellent definition, and with a power
of more than 1100 diameters, whenever one pleases and as long
as one pleases.

I have no hesitation in saying that a study of our Moon
negatives alone is capable of giving more information regarding
the lunar surface than has been obtained by all the laborious
years of observation by the most famous observers—Mädler,
Lohrmann, Schmidt, and others now living.

It is simply necessary to study *two* sets of negatives, the
second being necessary as a control on the first. Lest the above
may seem to be too sanguine I will give one discovery I have
lately made on our Moon negative of August 14, 1888.

It is well known that Mädler (and others) have mapped
the walls of the Hyginus rill crossing the floor of the Hyginus
crater. The observation is a delicate one and can only be made
when the Sun is shining nearly in the direction of the preceding
branch of this rill. Although this feature has often been
mapped I think it has seldom been observed.

The walls inside the crater are hardly more than 1000 to
2100 yards apart, and their bright tops are not more than 200
to 220 yards wide. Yet I see these walls entirely well in the
positive enlargement mentioned. From this single example it is
possible to form a judgment of the results which a competent
selenographer could draw from a suitably selected series of our
Moon negatives. It is my intention to obtain such series as soon
as practicable, and I shall offer a set, in the name of the Lick
Observatory, to the Royal Astronomical Society in the hope that
some "lonely and athletic student" may be willing to devote
the two or three years necessary to their thorough and exhaus-
tive study. It is not possible with the force at the disposition of
the Lick Observatory to undertake more than the production of
the materials for such a study. The study itself must, for the
present at least, be left to others.

Lick Observatory, Mount Hamilton :
    1889 *November* 23.

    * See, however, a paper by Dr. Elkin in the *Astronomical Journal*, vol. ix.
p. 35.

Observations of the Eclipse of Iapetus in the Shadows of the Globe, Crape Ring, and Bright Ring of Saturn, 1889 November 1. By E. E. Barnard, M.A., Astronomer of the Lick Observatory.

Astronomers are, indeed, indebted to Mr. A. Marth for his keen foresight of some of the rarer phenomena of the planets and satellites that are out of the regular line of the almanac predictions.

A brilliantly clear sky and ordinarily good seeing here on the morning of November 2, permitted observations of a portion of the series of eclipses of *Iapetus* in the shadows of the globe and ring-system of *Saturn*, to which attention had been called by Mr. Marth in the June number of the *Monthly Notices.*

Professor Holden requested me to observe this phenomenon with the 12-inch equatorial, as it would be out of the reach of the great telescope.

As soon as *Saturn* became visible above the horizon I examined it, and made a sketch of the positions of the satellites for reference later.

At sidereal time, 4ʰ 30ᵐ, *Titan, Tethys, Enceladus, Dione,* and *Rhea* were visible, as given in the order of right ascension; the two last were following the planet. *Tethys* and *Enceladus* were quite near each other, close preceding the end of the ring. A sharp watch was kept at the approximate point of reappearance of *Iapetus* from the shadow of the globe. The time was recorded every few minutes, and a note made that the satellite was not visible. The last of these was at 5ʰ 17½ᵐ sidereal time, when no trace of the satellite could be seen. At 5ʰ 25ᵐ sidereal time the satellite was faintly caught, and for at least one half minute before this it was seen, but so faint and uncertain that it was not recorded. At the above time it was about as bright as *Enceladus.* Its light increased pretty rapidly. The point of appearance formed a right-angled triangle with *Tethys* and *Enceladus,* the right angle at *Tethys, Iapetus* being nearly due north of that satellite.

The idea at once occurred that it would be an excellent plan to test the effect of the shadow of the crape ring on the visibility of the satellite, by frequent comparisons of the light of *Iapetus* with that of *Tethys* and *Enceladus.* A series of comparisons was therefore begun. The standard of comparison was the difference of brightness between *Tethys* and *Enceladus*—this quantity being mentally divided into ten equal parts. Seventy-five such comparisons were made during the visibility of *Iapetus.* I have constructed a curve from these, using normals, of three estimates each, between comparisons 6 and 74, and through the points so found I have drawn the curve that best represents them (see figure, where the single comparisons are represented by dots, and where the curve is drawn by the aid of the normals). I have laid off time on the axis of *x*, and brightness on the axis of *y*.

The records that follow are in local sidereal time, as were the preceding.
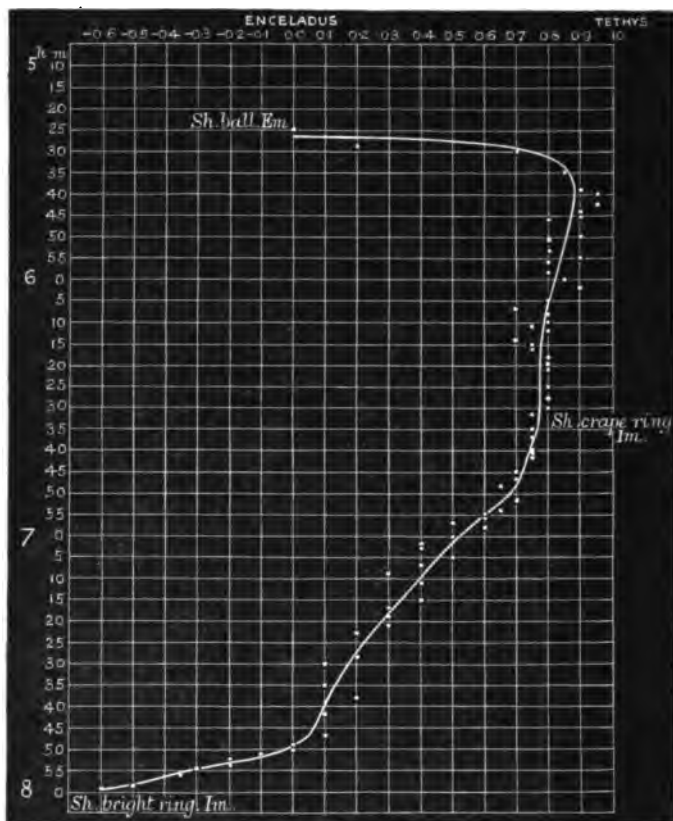
Light Curve of the Eclipse of *Iapetus*, in the shadows of the Globe, Crape Ring, and Bright Ring of *Saturn*, 1889 Nov. 1.

If we examine the curve we shall see that the satellite quickly attained its maximum light at about $5^h 35^m$. After this there was seemingly a slow decrease until about $6^h 15^m$. From this time until $6^h 35^m$ the light of the satellite seemed to be constant or almost imperceptibly to diminish. At $6^h 35^m$ a steady and decided decrease commenced and continued until $7^h 50^m$, when the satellite began rapidly to disappear, the curve sinking quite sharply.

I do not understand the slight decrease of light so soon after the maximum had been reached, as it is evident from the curve that the satellite did not experience the effects of the crape ring until near $6^h 35^m$. If, however, we consider that the varia-

tion of light between 5^h 40^m and 6^h 15^m represents only 0·1 of a
magnitude, it has less signification. (I am assuming with Prof.
Pickering that the difference between *Enceladus* and *Tethys* was
only one magnitude. See *Harvard College Observatory Annals*,
vol. xi. p. 269. To me the difference in their light appeared some-
what greater than this.) I would rather refer this peculiarity
to the fact that the seeing became better, and a fairer estimation
could therefore be made of the relative light; if so, the curve
should be flatter near 5^h 35^m, to correspond with that near
6^h 25^m.

This curve shows admirably how the semi-shadow of the
crape ring affected the visibility of *Iapetus*. There was a
regular decrease of the light of the satellite caused by this
shadow, from 6^h 35^m to 7^h 45^m, at which time *Iapetus* evidently
struck the shadow of the inner bright ring into which it disap-
peared, being last seen at 7^h 59^m.

The observations show that after passing through the sun-
light shining between the ball and the rings, *Iapetus* entered the
shadow of the crape ring. As it passed deeper into this the
absorption of sunlight became more and more pronounced, until
finally the satellite entered the shadow of the bright ring.

In a word, then, the crape ring is truly transparent—the
sunlight sifting through it. The particles composing it cut off
an appreciable quantity of sunlight. They cluster more thickly,
or the crape ring is denser as it approaches the bright rings.

A magnifying power of 150 was used throughout on the
12-inch. The seeing ranged from 2 at the first observations of
Iapetus up to 5 as dawn appeared.

Enceladus was last seen very faintly at 8^h 52^m sidereal time,
and had certainly disappeared in the whitening sky at 8^h 53^m.

Tethys disappeared at 8^h 57^m; this was the last glimpse of
it, the sky being quite white.

The following are the important instants, in Mount Hamilton
mean time:—

$$\text{h} \qquad \text{m}$$

Iapetus first certainly seen at 14 37·4, November 1, 1889.

„   last   „   „ at 17 11·0, November 1, 1889.

The superb definition of the planet in the last part of the
observations showed no abnormal appearance of the rings where
the shadow of the ball crosses them, nor have I at any time seen
a white spot on the rings at this or any other point.

In the diagram of the curve, the vertical column of figures
represents the sidereal times of the individual estimations, while
the horizontal column above gives the difference of light between
Enceladus and *Tethys* in steps of one-tenth each.

The observations of the disappearance of the satellite
(*Iapetus*) into the shadow of the bright ring show that, so far
as the penetration of the solar rays is concerned, the bright ring
is fully as opaque as the globe of *Saturn* itself.

TABLE OF LIGHT VARIATIONS OF IAPETUS.

November 1, 1889.

No.	Local Sid. Time.	Estimated Relative Light.	No.	Local Sid. Time.	Estimated Relative Light.
	h m			h m	
1	5 25·0	0·00	39	6 45·0	0·70
2	29·0	0·20	40	46·5	0·70
3	30·0	0·70	41	48·0	0·65 "decidedly fainter."
4	35·0	0·85	42	52·0	0·70
5	39·0	0·90	43	54·0	0·65
6	40·0	0·95	44	55·0	0·60
7	42·5	0·95	45	55·5	0·60
8	44·0	0·90	46	57·0	0·50
9	45·0	0·90	47	58·0	0·60
10	46·0	0·80	48	7 0·0	0·50
10½	50·0	0·90	49	2·0	0·40
11	51·0	0·80	50	3·0	0·40
12	53·0	0 80	51	5·0	0·50
13	55·0	0·90	52	7·0	0·40
14	56·0	0·80	53	9·0	0·30
15	58·0	0·80	54	11·0	0·40
16	6 0·0	0·85	55	15·0	0·40
17	2·0	0·90	56	17·0	0·30
18	5·0	0·80	57	19·0	0·30
19	7·0	0·70 "fainter."	58	21·0	0·30
20	8·0	0·80 "not fainter."	59	23·0	0·20
21	10 0	0·80	60	28·0	0·20
22	11 0	0·75 "fainter."	61	30·0	0·10
23	12·0	0·80	62	35·0	0·10
24	14·0	0·70 "fainter."	63	38·0	0·20
25	15·0	0·75	64	42·0	0·10
26	16·0	0·75	65	47·0	0·10
27	18 0	0·80	66	49·0	0·00
28	20·0	0·80	67	50·0	0·00 "perhaps slightly
29	21·0	0·80			less."
30	25·0	0·80	68	51·0	−0·10
31	27·5	0 80	69	52·5	−0·20
32	30·0	0·80	70	54·0	− 0 20
33	32 0	0·75	71	54·5	−0·30
34	35·0	0·75	72	56·0	−0·35 "v. v. faint."
35	37·0	0·75	73	58·0	−0·50 "e. e. faint."
36	40·0	0·75	74	59·0	−0·60 "e. e. e. faint."
37	41·0	0·75	75	8 1·0	"no trace of it."
38	42·0	0·75	76	8 5·0	„ „

Mount Hamilton :
  1889 *November* 22.

*Spectroscopic Results for the Motions of Stars in the Line of Sight,
obtained at the Royal Observatory, Greenwich, in the year 1889.
No. XIII.*

The results here given are in continuation of those printed in
the *Monthly Notices*, vol. xxxvi. p. 318, vol. xxxvii. p. 32,
vol. xxxviii. p. 493, vol. xli. p. 109, vol. xlii. p. 230, vol. xliii.
p. 81, vol. xliv. p. 89, vol. xlv. p. 330, vol. xlvi. p. 126, vol. xlvii.
p. 101, vol. xlviii. p. 116, and vol. xlix. p. 127. The observations
were made with the "half-prism" spectroscope, one "half-
prism," with a dispersion of about $18\frac{1}{2}°$ from A to H, being used
throughout. A magnifying power of 14 was employed.

The cylindrical lens has always been used in front of the slit
as in the observations made previously to 1881 and since 1882
March 14. The observations of the Sun, Moon, and planets have
been made as a check on the general accuracy of the results.

The day specified in the first column is the civil day, and the
hour is that of Greenwich civil time, commencing at Greenwich
mean midnight, and reckoning from 0 to 24 hours.

The observations were made by Mr. Maunder throughout.

*Motions of Stars in the Line of Sight in Miles per Second, observed with the
Half-prism Spectroscope.*

(+ denotes Recession ; − Approach.)

Date. 1889.		No. of Meas.	Line	Earth's Motion in miles per sec.	Concluded Motion of Star. Measd.	Estimd.	Remarks.
				a Andromedæ.			
	h						
Jan. 1	20	2	F	+ 17·1	− 50·4	− 59·7	Spectrum bright and steady.
July 31	23	2	F	− 14·4	− 34·7	− 23·1	Definition poor.
Sept. 6	23	2	F	− 7·7	− 13·9	− 15·0	Spectrum faint. Observed with difficulty.
16	23	2	F	− 5·2	− 22·5	− 24·5	Definition poor.
18	23	2	F	− 4·7	− 22·0	− 15·8	Star-line seen well.
25	23	2	F	− 2·8	− 11·5	− 9·4	Definition bad.
Oct. 30	21	2	F	+ 7·1	− 31·9	− 36·0	Definition bad.
Nov. 25	21	2	F	+ 13·3	− 49·0	− 46·4	Definition poor.
				β Cassiopeiæ.			
July 31	22	2	F	− 11·1	− 27·4	− 15·6	Definition poor.
Sept. 19	0	2	F	− 6·9	− 48·9	− 41·8	Star-line seen fairly well, but observing position very awkward.

Date. 1889.	No. of Meas.	Line.	Earth's Motion in miles per sec.	Concluded Motion of Star. Measd.	Concluded Motion of Star. Estimd.	Remarks.
				γ *Pegasi.*		
Sept. 16	23ʰ	2	F	− 4·1	− 19·1	− 22·6	Definition poor.
18	23	2	F	− 3·5	− 36·2	− 31·1	Spectrum faint, but steady.
Nov. 25	21	2	F	+ 15·4	− 35·5	− 36·9	Spectrum faint and tremulous.
				γ *Cassiopeiæ.*		
July 31	23	2	F	− 11·7	+ 21·3	+ 19·7	Spectrum faint; definition poor.
Sept. 19	0	2	F	− 8·7	− 21·3	− 18·2	Spectrum bright and steady.
				β *Arietis.*		
Jan. 1	21	2	F	+ 17·6	− 16·0	− 17·6	Star-line very broad and diffused.
Sept. 18	23	2	F	− 10·7	− 31·4	− 13·6	Spectrum bright and steady.
Nov. 25	22	2	F	+ 9·8	+ 20·1	+ 19·2	Definition poor.
				β *Persei.*		
Jan. 29	20	2	F	+ 16·9	− 16·5	− 9·0	Spectrum very faint.
Feb. 15	20	4	F	+ 17·4	− 15·5	− 14·2	Spectrum faint, but steady.
Sept. 17	0	2	F	− 14·6	− 33·1	− 35·7	Spectrum very faint.
18	23	4	F	− 14·3	+ 30·5	+ 33·2	Definition good.
26	0	4	F	− 13·3	− 34·0	− 29·2	Definition poor.
Nov. 25	21	4	F	+ 2·8	− 22·3	− 21·4	Definition poor.
				α *Persei.*		
Feb. 15	20	2	F	+ 16·2	− 36·0	− 43·3	Spectrum faint, but steady.
Sept. 17	0	2	F	− 14·4	+ 12·6	+ 9·9	Spectrum bright and steady.
18	23	2	F	− 14·2	+ 8·6	+ 8·5	Definition fair.
26	0	2	F	− 13·4	+ 12·7	+ 13·4	Definition good.
Nov. 25	20	2	F	+ 0·9	+ 19·8	+ 25·6	Spectrum and star-line faint.
				Aldebaran.		
Jan. 1	22	1	F	+ 10·4	+ 32·7	+ 35·2	Observation very rough.
Feb. 4	20	2	F	+ 17·4	− 1·5	+ 10·2	Star-line seen with difficulty.
15	21	4	F	+ 18·4	+ 30·7	+ 17·4	Star-line seen very well.
Mar. 5	21	2	*b₁*	+ 18·4	+ 51·1	+ 46·4	Spectrum *very* tremulous.
Sept. 19	0	2	F	− 17·2	+ 39·6	+ 39·6	Spectrum rather faint.
Nov. 25	22	2	F	− 1·4	+ 57·9	+ 67·6	Spectrum bright and steady.
Dec. 20	21	2	F.	+ 6·8	+ 79·8	+ 51·2	Observations very rough.

Date. 1889.		No. of Meas.	Line.	Earth's Motion in miles per sec.	Concluded Motion of Star.		Remarks.
					Measd.	Estimd.	

Capella.

Date. 1889.	h	No. of Meas.	Line.	Earth's Motion in miles per sec.	Measd.	Estimd.	Remarks.
Feb. 15	21	4	F	+ 16·0	+ 7·8	+ 7·0	Star-line seen fairly well.
Mar. 5	21	2	b_1	+ 17·1	+ 3·2	+ 3·6	Spectrum *very* tremulous.
Sept. 17	0	2	F	− 13·3	+31·3	+38·4	Definition poor.
19	0	4	F	− 16·7	+ 38·5	+40·4	Spectrum bright and steady.
26	0	2	F	− 16·5	+41·3	+40·8	Definition bad.
Nov. 25	22	2	F	− 4·9	+ 29·4	+ 33·9	Spectrum bright and steady.

Rigel.

Feb. 4	21	2	F	+ 14·1	+ 33·9	+41·0	Star-line seen fairly well.
8	21	2	F	+ 14·6	+ 6·2	+ 11·6	Star-line seen well.
15	22	2	F	+ 15·3	− 6·1	− 1·2	Spectrum very tremulous. Star-line seen with great difficulty.
Apr. 5	20	4	F	+ 13·4	+ 21·7	+ 14·7	Spectrum tremulous. Measures rough.
Nov. 25	23	2	F	− 3·5	+ 31·0	+ 33·3	Star-line seen well.
Dec. 20	22	2	F	+ 3·9	+ 33·8	+ 33·4	Spectrum very unsteady.

γ Orionis.

Feb. 4	21	4	F	+ 15·1	− 10·2	− 4·8	Star-line seen fairly well.
8	21	2	F	+ 15·8	− 9·6	− 5·1	Spectrum faint.
15	22	2	F	+ 16·7	−31·2	−28·1	Star-line seen fairly well.
Nov. 25	23	2	F	− 4·8	−13·5	−17·6	Star-line seen fairly well.
Dec. 20	22	4	F	+ 3·1	+ 9·7	+ 6·8	Star-line seen fairly well.

β Tauri.

Feb. 4	21	2	F	+ 15·5	− 14·9	− 2·6	Spectrum faint. Cloudy.
8	21	2	F	+ 16·1	−25·7	−23·3	Star-line seen with difficulty.
15	21	2	F	+ 17·2	− 17·6	− 14·0	Star-line seen well.
Sept. 26	0	2	F	− 17·8	+ 16·9	+ 17·8	Definition fair.
Nov. 25	23	2	F	− 5·9	+ 40·0	+ 37·4	Star-line seen fairly well.
Dec. 20	22	2	F	+ 2·7	+ 29·5	+ 19·7	Star-line seen fairly well.

δ Orionis.

Apr. 5	21	2	F	+ 15·1	+11·2	+ 10·2	Spectrum faint. Measures rough.
Nov. 25	23	2	F	− 5·0	+ 11·0	+ 10·0	Star-line seen with difficulty.
Dec. 20	23	2	F	+ 2·6	+ 8·7	+ 2·4	Star-line seen fairly well.

Date. 1889.	No. of Meas.	Line.	Earth's Motion in miles per sec.	Concluded Motion of Star. Measd.	Estimd.	Remarks.

ε Orionis.

Nov. 25 23ʰ	2	F	− 5·3	+ 14·4	+ 17·7	Star-line seen fairly well.
Dec. 20 23	2	F	+ 2·2	+ 15·0	+ 12·7	Star-line seen fairly well.

ζ Orionis.

Nov. 26 0	4	F	− 5·6	+ 3·2	+ 5·6	Star-line seen fairly well.
Dec. 20 23·	2	F	+ 1·9	+ 27·1	+ 13·0	Star-line seen fairly well.

α Orionis.

Mar. 5 22	4	b_4	+ 17·5	+ 2·6	+ 9·1	Star-line seen with great difficulty. Measures rough.

β Aurigæ.

Feb. 15 21	2	F	+ 15·0	− 3·5	+ 1·2	Spectrum bright and steady
Sept. 26 0	4	F	− 17·0	− 0·6	+ 6·4	Definition poor.
Nov. 25 22	2	F	− 7·3	+ 31·9	+ 27·2	Spectrum fairly bright, but star-line faint.

γ Geminorum.

Feb. 15 23	4	F	+ 14·3	− 75·0	− 63·1	Spectrum faint but steady.
Dec. 20 23	2	F	− 2·7	− 50·5	− 33·7	Star-line seen very well.

Sirius.

Feb. 8 22	6	F	+ 8·9	− 13·2	− 13·1	Measures made with difficulty.
15 22	6	F	+ 10·2	− 31·7	− 28·4	Spectrum very unsteady.
Mar. 27 21	4	F	+ 14·1	− 43·7	− 49·5	Spectrum very unsteady.
Apr. 15 20	4	F	+ 13·7	− 44·0	− 45·5	Spectrum faint, and very unsteady. Measures very rough.
Nov. 26 0	6	F	− 9·1	+ 3·8	+ 7·5	Spectrum very unsteady.
Dec. 21 0	4	F	− 3·3	− 51·8	− 38·1	Spectrum very unsteady.

Castor.

Feb. 15 23	2	F	+ 11·6	+ 34·7	+ 23·1	Definition good.
Mar. 27 22	2	F	+ 17·8	− 37·1	− 43·2	Spectrum and star-line faint.
Apr. 25 22	2	F	+ 17·0	− 13·4	− 7·0	Spectrum faint.
Dec. 21 0	2	F	− 6·2	+ 33·5	+ 23·6	Star-line seen well.

Procyon.

Feb. 8 22	2	F	+ 8·0	− 9·5	− 11·6	Star-line faint.
15 23	4	F	+ 9·9	− 7·9	− 5·8	Star-line faint.
Mar. 27 22	2	F	+ 16·9	− 6·7	− 8·9	Spectrum fairly steady.
Apr. 15 21	1	F	+ 17·5	− 43·0	− 51·0	Observations interrupted by cloud.
Dec. 21 0	4	F	− 7·7	+ 6·7	+ 7·7	Star-line seen fairly well.

Date. 1889.	No. of Meas.	Line.	Earth's Motion in miles per sec.	Concluded Motion of Star. Measd.	Estimd.	Remarks.

Pollux.

Date. 1889.	No. of Meas.	Line.	Earth's Motion in miles per sec.	Concluded Motion of Star. Measd.	Estimd.	Remarks.
Feb. 8 23	2	F	+ 9·0	− 13·0	− 16·1	Star-line seen with difficulty.
15 23	2	F	+ 10·9	− 52·7	− 43·5	Star-line faint.
Mar. 5 22	2	b_1	+ 15·0	− 43·2	− 49·4	Spectrum very unsteady, but star-line sharp.
27 22	2	F	+ 17·7	− 53·4	− 60·5	Star-line seen fairly well.
Dec. 21 0	2	F	− 7·2	− 12·6	− 7·7	Star-line very faint.

Regulus.

Date. 1889.	No. of Meas.	Line.	Earth's Motion in miles per sec.	Concluded Motion of Star. Measd.	Estimd.	Remarks.
Feb. 15 23	2	F	− 0·3	+ 25·2	+ 19·3	Spectrum seen well.
Mar. 27 22	2	F	+ 11·6	+ 13·3	+ 11·8	Observations made with difficulty.
Apr. 25 22	4	F	+ 16·7	+ 20·4	+ 20·7	Star-line seen well.
30 22	2	F	+ 17·2	− 24·2	− 22·1	Spectrum bright but tremulous. Star-line faint, and seen with difficulty.
May 2 23	2	F	+ 17·4	+ 16·3	+ 20·7	Spectrum bright and fairly steady.

γ Leonis.

Date. 1889.	No. of Meas.	Line.	Earth's Motion in miles per sec.	Concluded Motion of Star. Measd.	Estimd.	Remarks.
Mar. 5 23	2	b_1	+ 5·5	− 30·7	− 39·9	Spectrum bright but very tremulous.
27 23	2	F	+ 11·5	− 18·2	− 25·5	Star-line seen with great difficulty. Measures rough.
Apr. 30 22	2	F	+ 17·0	+ 14·7	+ 17·8	Spectrum bright and fairly steady. Star-line faint.

β Ursæ Majoris.

Date. 1889.	No. of Meas.	Line.	Earth's Motion in miles per sec.	Concluded Motion of Star. Measd.	Estimd.	Remarks.
May 2 22	4	F	+ 12·7	− 25·1	− 26·7	Spectrum bright and steady. Star-line seen well.

α Ursæ Majoris.

Date. 1889.	No. of Meas.	Line.	Earth's Motion in miles per sec.	Concluded Motion of Star. Measd.	Estimd.	Remarks.
May 2 21	4	F	+ 11·7	− 29·3	− 27·8	Spectrum bright and steady. Star-line seen well.

δ Leonis.

Date. 1889.	No. of Meas.	Line.	Earth's Motion in miles per sec.	Concluded Motion of Star. Measd.	Estimd.	Remarks.
May 3 23	2	F	+ 15·5	− 63·1	− 52·8	Spectrum rather faint.

β Leonis.

Date. 1889.	No. of Meas.	Line.	Earth's Motion in miles per sec.	Concluded Motion of Star. Measd.	Estimd.	Remarks.
Mar. 27 23	2	F	+ 5·4	+ 8·4	+ 16·0	Spectrum bright and fairly steady. Star-line very broad, diffused, and difficult to bisect.
Apr. 30 22	4	F	+ 13·6	− 25·0	− 21·9	
May 2 23	4	F	+ 14·0	− 71·1	− 69·1	

γ Ursæ Majoris.

Date. 1889.	No. of Meas.	Line.	Earth's Motion in miles per sec.	Concluded Motion of Star. Measd.	Estimd.	Remarks.
May 2 22	4	F	+ 11·8	+ 4·2	+ 4·3	Spectrum bright and steady.

Date. 1889.	No. of Meas.	Line.	Earth's Motion in miles per sec.	Concluded Motion of Star. Measd.	Estimd.	Remarks.
				δ Ursæ Majoris.		
May 2 22ʰ	4	F	+ 10·7	− 15·5	− 15·7	Spectrum bright and steady; star-line seen well.
				γ Virginis.		
Mar. 27 23	2	F	− 0·4	+ 22·6	+ 30·5	Measures rough and made with difficulty.
May 2 23	2	F	+ 10·1	− 41·5	− 38·0	Spectrum and star-line faint.
				ε Ursæ Majoris.		
May 2 23	4	F	+ 9·5	− 7·4	− 9·5	Spectrum bright and steady.
				α Canum Venaticorum.		
Mar. 27 23	2	F	+ 3·5	− 55·1	− 54·3	Spectrum faint but steady.
				Spica.		
Mar. 27 23	2	F	− 4·7	+ 31·2	+ 32·8	Spectrum bright but very tremulous.
Apr. 15 23	2	F	+ 1·2	+ 46·0	+ 35·6	Spectrum bright but tremulous.
30 23	4	F	+ 5·7	− 9·8	− 10·5	Star-line faint.
May 2 23	2	F	+ 6·3	− 8·7	− 6·3	Spectrum very tremulous.
				ζ Ursæ Majoris.		
Mar. 28 0	4	F	+ 4·0	− 22·7	− 32·4	Spectrum bright and steady; observing-position very awkward and measures rough.
May 3 0	4	F	+ 8·5	− 6·7	− 8·5	Spectrum bright and steady.
				η Ursæ Majoris.		
Mar. 28 0	2	F	+ 2·3	− 62·6	− 69·1	Spectrum bright and steady; observing-position very awkward and measures rough.
May 3 0	4	F	+ 7·7	− 19·0	− 23·8	Spectrum bright and steady.
				η Boötis.		
Mar. 5 23	2	b_1	− 8·8	+ 44·0	+ 44·2	Star-line seen with difficulty. Measures rough.
				Arcturus.		
Mar. 6 0	2	b	− 9·7	− 49·3	− 49·2	Spectrum bright but tremulous. Measures very accordant.
22 0	2	F	− 5·5	− 29·0	− 20·9	Spectrum faint and tremulous.
28 0	2	F	− 4·1	− 31·9	− 40·1	Spectrum bright but tremulous.

Date. 1889.		No. of Meas.	Line.	Earth's Motion in miles per sec.	Concluded Motion of Star. Measd.	Estimd.	Remarks.
Apr.	h 15 22	2	F	+ 0·9	−24·7	−31·0	Spectrum bright but tremulous.
	30 23	2	F	+ 4·8	−25·1	−38·0	Star-line faint.
May	3 0	2	F	+ 5·3	−45·9	−47·4	Spectrum very bright but tremulous.
June	27 0	2	F	+14·6	−67·2	−61·5	Spectrum bright but very tremulous.

γ Boötis.

Apr.	30 23	2	F	+ 4·9	−69·1	−63·0	Spectrum rather faint, but steady.

ε Boötis.

Mar.	6 0	2	b_1	− 9·3	−13·8	−39·2	Star-line seen with difficulty. Measures rough.

β Libræ.

Apr.	30 23	2	F	− 2·2	−27·4	−26·8	Spectrum fairly bright, but tremulous.

α Coronæ Borealis.

Mar.	22 1	2	F	− 8·2	+ 8·8	+ 8·2	Definition poor. Measures rough.
Apr.	30 23	2	F	0·0	+27·6	+21·5	Spectrum bright, and fairly steady.
June	27 0	4	F	+10·4	−13·1	− 6·9	Spectrum very tremulous. Measures very rough.
July	15 23	4	F	+12·2	+24·9	+29·2	Spectrum bright, but tremulous.

β Serpentis.

Apr.	30 23	2	F	− 2·0	−40·6	−39·5	Spectrum faint, but fairly steady.

α Ophiuchi.

Apr.	30 23	2	F	− 9·4	+56·1	+59·2	Spectrum bright, and fairly steady.
June	27 0	2	F	+ 3·6	−33·3	−38·8	Definition poor.
July	15 23	2	F	+ 7·8	−36·1	−30·0	Spectrum bright, but tremulous.
	19 23	4	F	+ 8·6	−34·8	−36·4	Spectrum fairly bright and steady.

Vega.

Apr.	30 23	4	F	− 7·6	−22·6	−20·6	Spectrum very bright and steady.
June	27 1	2	F	− 1·2	− 3·3	− 8·2	Spectrum very tremulous.
July	16 0	4	F	+ 1·4	−22·0	−24·6	Definition poor.
	19 23	4	F	+ 2·0	−22·4	−27·0	Spectrum very bright.
Sept.	6 21	2	F	+ 7·5	−59·7	−54·4	Definition fair.
	13 21	2	F	+ 8·0	−47·0	−41·9	Definition poor.
	16 20	2	F	+ 0·8	−35·0	−38·9	Star-line seen well.
	18 21	2	F	+ 8·2	−56·2	−49·8	Definition fair.

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Date. 1889.	No. of Meas.	Line.	Earth's Motion in miles per sec.	Concluded Motion of Star. Measd.	Estimd.	Remarks.
				γ *Lyræ.*		
Sept. 18 21ʰ	2	F	+ 9·5	−82·1	−63·9	Spectrum very faint. Measures rough, and made with great difficulty.
				ζ *Aquilæ.*		
July 15 23	4	F	+ 1·3	−22·6	−23·6	Star-line seen fairly well.
19 23	2	F	+ 2·3	−48·2	−46·8	Spectrum faint. Star-line difficult to bisect.
Sept. 18 21	2	F	+13·6	−25·6	−27·1	Spectrum very faint. Measures rough, and made with great difficulty.
				δ *Aquilæ.*		
July 19 23	2	F	+ 1·5	−34·3	−29·3	Spectrum very faint. Measures rough.
				δ *Cygni.*		
Sept. 18 21	2	F	+ 5·2	+ 9·4	+ 7·6	Spectrum very faint. Measures rough.
				Altair.		
June 27 0	2	F	− 6·5	−44·8	−40·4	Observations interrupted by cloud.
July 16 0	4	F	− 1·8	−26·0	−24·0	Definition poor.
20 0	2	F	− 0·8	−50·0	−49·3	Spectrum bright and steady.
Sept. 6 22	2	F	+11·0	−41·0	−40·8	Definition fair.
13 21	2	F	+12·3	−34·0	−35·5	Definition poor.
16 21	4	F	+12·8	−34·6	−39·9	Star-line seen fairly well.
18 22	4	F	+13·2	−37·1	−39·1	Definition fair.
25 22	2	F	+14·2	−39·1	− 41·0	Spectrum faint and tremulous.
				a *Cygni.*		
June 27 1	2	F	− 7·6	−43·6	−34·6	Definition good.
July 16 0	2	F	− 5·8	−51·5	−49·8	Star-line seen fairly well.
20 0	2	F	− 5·3	−39·0	−41·1	Observing-position very awkward.
31 22	2	F	− 3·8	−50·6	−27·4	Definition poor.
Sept. 6 23	2	F	+ 1·7	−27·6	−35·8	Star-line faint and seen with difficulty.
13 22	2	F	+ 2·7	−26·2	−32·8	Star-line faint and seen with difficulty.
16 21	2	F	+ 3·2	−64·1	−61·1	Observing-position awkward.
18 22	2	F	+ 3·5	−32·4	−32·3	Definition fair.
25 23	2	F	+ 4·5	−59·5	−50·1	Definition good.
				a *Cephei.*		
July 20 0	2	F	− 6·2	−78·4	−67·9	Observing-position very awkward.
31 22	2	F	− 5·7	−44·9	−23·3	Definition poor.

Date. 1889.	No. of Meas.	Line.	Earth's Motion in miles per sec.	Concluded Motion of Star. Measd.	Concluded Motion of Star. Estimd.	Remarks.
Sept. 16 22ʰ	2	F	− 1·9	−30·9	−34·7	Observing-position very awkward. Measures rough.
25 23	2	F	− 0·9	−53·6	−42·9	Star-line seen with great difficulty. Measures rough.

a Pegasi.

Date. 1889.	No. of Meas.	Line.	Earth's Motion in miles per sec.	Concluded Motion of Star. Measd.	Concluded Motion of Star. Estimd.	Remarks.
Sept. 13 22	1	F	− 0·2	−56·3	−46·1	Observations interrupted by cloud.
16 22	2	F	+ 0·7	−30·9	−31·2	Star-line seen fairly well.
18 22	2	F	+ 1·3	−53·0	−50·0	Spectrum faint. Measures rough and made with difficulty.

Venus.

Date. 1889.	No. of Meas.	Line.	Earth's Motion in miles per sec.	Concluded Motion of Star. Measd.	Concluded Motion of Star. Estimd.	Remarks.
Feb. 4 19	2	F	...	+20·1	+18·1	Calculated motion −7·8 miles per second.
15 21	2	F	...	−14·9	−11·4	Calculated motion −8·0 miles per second.

Moon.

Date. 1889.	No. of Meas.	Line.	Earth's Motion in miles per sec.	Concluded Motion of Star. Measd.	Concluded Motion of Star. Estimd.	Remarks.	
Feb. 4 20	5	F	...	− 2·0	...		
15 23	5	F	...	+ 2·7	...	Measures made with pointer.	
16 0	5	F	...	+ 2·8	...	Measures made with spider-line.	The coincidence of the two spectra appeared perfect.
Apr. 5 21	5	F	...	+ 3·0	...		
15 21	8	F	..	− 1·5	...		
July 16 0	5	F	...	+ 0·3	...		
Sept. 6 22	5	F	...	− 1·6	...		
17 1	5	F	...	+ 1·6	...		
Dec. 3 21	5	F	...	+ 2·3	...		

Sun.

Date. 1889.	No. of Meas.	Line.	Earth's Motion in miles per sec.	Concluded Motion of Star. Measd.	Concluded Motion of Star. Estimd.	Remarks.
May 3 12	5	F	...	− 1·6	...	The coincidence of the two spectra appeared perfect.

Sky.

Date. 1889.	No. of Meas.	Line.	Earth's Motion in miles per sec.	Concluded Motion of Star. Measd.	Concluded Motion of Star. Estimd.	Remarks.
Feb. 9 12	5	F	...	+ 1·5	...	
Mar. 28 12	5	F	...	+ 1·3	...	The coincidence of the two spectra appeared perfect.
Aug. 1 11	5	F	...	+ 1·4	...	
Sept. 26 12	5	F	...	− 0·1	...	

Ring of Saturn.

Relative displacement of the preceding and following ansæ of Ring B immediately within the Cassinian division.

Date. 1889.	No. of Meas.	Line.	$p-f$ ansa.	Remarks.
Mar. 5 22ʰ	5	b_1	+ 37·0	Spectrum very faint; lines seen with great difficulty. Observations rough. Computed relative motion, + 19·4 miles per second.

L 2

Observations of Occultations of Stars by the Moon and of Phenomena of Jupiter's Satellites, made at the Royal Observatory, Greenwich, in the year 1889.

(Communicated by the Astronomer Royal.)

Occultations of Stars by the Moon.

Day.	Phenomenon.	Telescope.	Power.	Moon's Limb.	Mean Solar Time of Observation.	Observer.
					h m s	
1889, Feb. 9	Disapp. i Tauri	Altaz.	100	Dark	6 46 18·15	A. D.
12	,, 63 Geminorum	Altaz.	100	,,	7 40 47·33	H. T.
12	,, 63 Geminorum	E. Equat.	140	,,	7 40 47·49	H.
Sept. 16 (a)	,, ζ Tauri	Lassell Refl.	280	Bright	12 53 41·49	H. T.
16 (b)	,, ζ Tauri	Altaz.	100	,,	12 53 41·15	L.
16	Reapp. ζ Tauri	Lassell Refl.	280	Dark	13 36 55·29	H. T.
16	,, ζ Tauri	Altaz.	100	,,	13 36 55·96	L.
Oct. 5	Disapp. 56 Aquarii	Altaz.	100	,,	8 39 47·40	T.
29	,, Piazzi xix. 22	Altaz.	100	,,	6 30 57·95	W. R.
Dec. 31	,, 85 Ceti	E. Equat.	200	,,	5 4 58·36	O.
31	,, 85 Ceti	Altaz.	100	,,	5 4 57·86	H.

Notes.

(a) No projection. Disappeared instantaneously at bright limb,
(b) Star touched the Moon's limb 5 seconds before time of observation, was wholly inside the limb at 12h 53m 40s; it appeared as a brilliant spot on the Moon, and disappeared suddenly at time given above.

For the occultation of *Jupiter* on August 7 and of Satellites II. and IV., see vol. 1. p. 36.

Phenomena of Jupiter's Satellites.

Day.	Satellite.	Phenomenon.		Telescope.	Power.	Mean Solar Time of Observation.	Mean Solar Time of N.A.	Observer.
						h m s	h m s	
1889 Apr. 22 (a)	III.	Ecl. D.	Last seen	E. Equat.	140	14 5 25	14 4 35	J. P.
May 21 (b)	I.	Occ. R.	Last contact	Lassell Refl.	280	13 22 0	13 20 0	H. T.
29 (c)	I.	Tr. Egr.	First contact	Altaz.	100	12 11 34	12 13 0	A. D.
29	I.		Last contact	,,	,,	12 14 53		,,
31 (d)	II.	Occ. R.	First seen	Lassell Refl.	280	13 56 7	13 56 0	H.
31	II.		Full brightness	,,	,,	14 4 47		,,
June 4	I.	Ecl. D.	Began to fade	,,	,,	14 5 40	14 7 23	,,
4	I.		Last seen	,,	,,	14 7 50		,,
July 6	I.	Occ. D.	First contact	Corbett Refr.	110	10 16 8		A. D.
6	I.		Bisection	,,	,,	10 19 22		,,
6	I.		Last seen	,,	,,	10 22 28		,,
6 (e)	I.		First contact	Lassell Refl.	280	10 17 45	10 22 0	L.
6	I.		Bisection	,,	,,	10 19 55		,,
6	I.		Last seen	,,	,,	-10 22 30		,,
15	I.	Ecl. R.	First seen	Altaz.	100	9 18 6	9 17 28	T.

Day.	Satellite.	Phenomenon.	Telescope.	Power.	Mean Solar Time of Observation. h m s	Mean Solar Time of N.A. h m s	Observer.
1889 July 18	II.	Tr. Egr. First contact	Lassell Refl.	280	11 34 9		A.D.
18	II.	Bisection	"	"	11 35 39	11 37 0	"
18	II.	Last contact	"	"	11 38 13		"
Aug. 6	I.	Tr. Egr. First contact	Altaz.	100	11 13 54	11 16 0	T.
6	I.	Last contact	"	"	11 17 39		"
15	III.	Ecl. R. First seen	Lassell Refl.	280	8 34 35		H.T.
15 (f)	III.	First seen	E. Equat.	200	8 35 27		C.
15	III.	Full brightness	"	"	8 37 57	8 37 16	J.P.
15 (g)	III.	First seen	Altaz.	100	8 36 30		"
15	III.	Full brightness	"	"	8 38 37		"
28	II.	Ecl. R. First seen	"	"	9 18 30		L.
28	II.	Full brightness	"	"	9 19 38	9 17 47	"
29	III.	Occ. D. First contact	"	"	8 55 4		S.D.
29	III.	Last seen	"	"	8 57 54	8 46 0	"
Sept. 6	I.	Occ. D. First contact	Lassell Refl.	280	8 2 44		A.D.
6	I.	Bisection	"	"	8 5 1	8 8 0	"
6	I.	Last seen	"	"	8 7 23		"
12 (h)	IV.	Tr. Egr. Last contact	E. Equat.	210	7 26 31	7 38 0	A.D.

Day.	Satellite.	Phenomenon.	Telescope.	Power.	Mean Solar Time of Observation.	Mean Solar Time of N.A.	Observer.
					h m s	h m s	
1889 Oct. 7 (i)	I.	Tr. Ing. Bisection	E. Equat.	140	7 25 20		H.
7	I.	Last contact	"	"	7 28 0		"
7 (k)	I.	First contact	Altaz.	100	7 21 18	7 29 0	A. P.
7	I.	Bisection	"	"	7 24 8		"
7	I.	Last contact	"	"	7 27 17		"

Notes.

(a) *Jupiter* diffused.   (b) Definition too poor to permit observation of "First Seen." The satellite was well clear of *Jupiter* at 13h 23m 30s.

(c) *Jupiter* very tremulous and ill-defined. Observation uncertain.

(d) Observation *very* uncertain; limb of *Jupiter* boiling.   (e) Satellite very faint; cloudy.

(f) Clouds passing.   (g) Suspected at 8h 35m 53s.   (h) Satellite very faint; not noticed until near last contact.

(i) Image not good.   (k) Satellite faint; *Jupiter* diffused.

The clear aperture of the mirror of the Lassell Reflector is 24 inches, of the object-glass of the E. Equatorial 6·7 inches, of the Corbett Refractor 6½ inches, and of the Altazimuth 3¾ inches.

The initials H. T., C., A. D., T., L., H., J. P., A. P., S. D., and W. R., are those of Mr. Turner, Mr. Criswick, Mr. Downing, Mr. Thackeray, Mr. Lewis, Mr. Hollis, Mr. Power, Mr. A. Pead, Mr. Dolman, and Mr. Russell respectively.

Ephemeris of the Satellites of Uranus, 1890.   By A. Marth.

		Ariel.			Umbriel.		
Greenwich Noon.	P	a_1	b_1	u_1-U	a_2	b_2	u_2-U
1890.	°	″	″	°	″	″	°
Feb. 26	281·31	14·88	+ 9·52	101·55	20·74	+ 13·27	223·16
Mar. 8	·39	14·98	9·53	89·94	20·87	13·28	11·85
18	·49	15·06	9·52	78·29	20·99	13·26	160·51
28	·60	15·12	9·48	66·61	21·07	13·21	309·15
Apr. 7	·72	15·16	9·42	54·91	21·11	13·12	97·76
17	·84	15·16	9·33	43·19	21·12	13·00	246·37
27	281·95	15·15	9·23	31·44	21·10	12·86	34·96
May 7	282·06	15·10	+ 9·12	19·67	21·04	+ 12·71	183·54
17	·15	15·03	9·01	7·89	20·95	12·55	332·12
27	·23	14·95	8·89	356·10	20·82	12·39	120·70
June 6	·29	14·84	8·78	344·31	20·68	12·24	269·28
16	·33	14·73	8·68	332·52	20·52	12·09	57·87
26	·34	14·60	8·59	320·74	20·34	11·97	206·47
July 6	·33	14·47	8·52	308·97	20·16	11·86	355·09
16	282·31	14·34	+ 8·46	297·22	19·98	+ 11·78	143·72

	Titania.			Oberon.				
	a_3	b_3	u_3-U	a_4	b_4	u_4-U	U	B
	″	″	°	″	″	°	°	°
Feb. 26	34·01	+ 21·76	138·97	45·48	+ 29·10	2·62	359·72	+ 39·78
Mar. 8	34·24	21·78	192·45	45·79	29·14	269·97	359·78	39·51
18	34·42	21·75	245·91	46·03	29·09	177·30	359·86	39·19
28	34·56	21·66	299·35	46·21	28·96	84·62	359·94	38·82
Apr. 7	34·63	21·51	352·78	46·32	28·77	351·93	0·03	38·41
17	34·65	21·32	46·21	46·34	28·52	259·24	0·12	37·99
27	34·61	21·10	99·63	46·28	28·22	166·54	0·21	37·57
May 7	34·51	+ 20·85	153·05	46·15	+ 27·88	73·85	0·29	+ 37·17
17	34·36	20·59	206·47	45·94	27·53	341·16	0·36	36·82
27	34·16	20·32	259·90	45·68	27·18	248·48	0·42	36·52
June 6	33·92	20·06	313·34	45·37	26·84	155·81	0·46	36·28
16	33·65	19·83	6·79	45·00	26·53	63·16	0·48	36·12
26	33·36	19·63	60·26	44·62	26·25	330·52	0·49	36·04
July 6	33·07	19·46	113·75	44·22	26·02	237·90	0·48	36·04
16	32·77	+ 19·32	167·25	43·82	+ 25·84	145·30	0·45	+ 36·13

The values of P, a, b, $u-U$ are to be interpolated for the times for which the apparent positions of the satellites are

required (the degrees of the differences of successive values of $u - U$ being in the case of *Ar.* 1428°, *Um.* 868°, *Tit.* 413°, *Ob.* 267°), and the position-angles p and distances s are then found by means of the formulæ—

$$s \sin (p - P) = a \sin (u - U)$$
$$s \cos (p - P) = b \cos (u - U).$$

The satellites will be at their greatest elongations (N in position-angle $P + 90°$, S in position $P - 90°$) and at their conjunctions with the planet's centre (superior conjunction in position-angle P, inferior conjunction in position $P - 180°$) at the following hours, Greenwich mean time:—

Ariel.

1890.	N. Elong. h	S. Elong. d h		N. Elong. h	S. Elong. d h		N. Elong. h	S. Elong. d h
Mar. 2	23·0	4 5·3	Apr. 9	18·4	11 0·6	May 17	13·8	18 20·0
5	11·5	6 17·8	12	6·9	13 13·1	20	2·3	21 8·5
8	0·0	9 . 6·3	14	19·4	16 1·6	22	14·8	23 21·0
10	12·5	11 18·7	17	7·9	18 14·1	25	3·3	26 9·5
13	1·0	14 7·2	19	20·4	21 2·6	27	15·8	28 22·0
15	13·5	16 19·7	22	8·9	23 15·1	30	4·3	31 10·5
18	2·0	19 8·2	24	21·3	26 3·6	June 1	16·8	2 23·0
20	14·5	21 20·7	27	9·8	28 16·1	4	5·3	5 11·5
23	2·9	24 9·2	29	22·3	M.1 4·6	6	17·8	8 0·0
25	15·4	26 21·7	May 2	10·8	3 17·1	9	6·3	10 12·5
28	3·9	29 10·2	4	23·3	6 5·6	11	18·7	13 1·0
30	16·4	31 22·7	7	11·8	8 18·1	14	7·2	15 13·5
Apr. 2	4·9	3 11·2	10	0·3	11 6·6	16	19·7	18 2·0
4	17·4	5 23·6	12	12·8	13 19·1	19	8·2	20 14·5
7	5·9	8 12·1	15	1·3	16 7·6	21	20·7	23 3·0

Umbriel.

	h	d h		h	d h		h	d h
Mar. 4	18·1	6 19·9	Apr. 11	1·3	13 3·1	May 18	8·6	20 10·3
8	21·6	10 23·3	15	4·8	17 6·5	22	12·0	24 13·8
13	1·1	15 2·8	19	8·3	21 10·0	26	15·5	28 17·3
17	4·5	19 6·3	23	11·7	25 13·5	30	19·0	J. 1 20·7
21	8·0	23 9·7	27	15·2	29 16·9	June 3	22·5	6 0·2
25	11·5	27 13·2	May 1	18·7	3 20·4	8	1·9	10 3·7
29	14·9	31 16·7	5	22·2	7 23·9	12	5·4	14 7·1
Apr. 2	18·4	4 20·1	10	1·6	12 3·4	16	8·9	18 10·6
6	21·9	8 23·6	14	5·1	16 6·8	20	12·3	22 14·1

Titania.

	h			h			h				h
Mar.	1	4·1	S.	Apr. 4	23·9		May 9	19·9	S.	June 13	15·8
	3	8·3	sup.	7	4·2		12	0·1	sup.	15	20·1
	5	12·5	N.	9	8·4		14	4·4	N.	18	0·3
	7	16·8	inf.	11	12·7		16	8·6	inf.	20	4·5
	9	21·0	S.	13	16·9		18	12·9	S.	22	8·8
	12	1·3	sup.	15	21·2		20	17·1	sup.	24	13·0
	14	5·5	N.	18	1·4		22	21·4	N.	26	17·3
	16	9·7	inf.	20	5·7		25	1·6	inf.	28	21·5
	18	14·0	S.	22	9·9		27	5·9	S.	July 1	1·7
	20	18·2	sup.	24	14·2		29	10·1	sup.	3	6·0
	22	22·5	N.	26	18·4		31	14·4	N.	5	10·2
	25	2·7	inf.	28	22·7		June 2	18·6	inf.	7	14·5
	27	7·0	S.	May 1	2·9		4	22·8	S.	9	18·7
	29	11·2	sup.	3	7·2		7	3·1	sup.	11	22·9
	31	15·5	N.	5	11·4		9	7·3	N. .	14	3·2
Apr.	2	19·7	inf.	7	15·6		11	11·6	inf.	16	7·4

Oberon.

	h			h			h				h
Mar.	1	6·4	N.	Apr. 10	16·0		May 21	1·7	N.	June 30	11·2
	4	15·2	inf.	14	0·9		24	10·5	inf.	July 3	20·0
	8	0·0	S.	17	9·7		27	19·3	S.	7	4·8
	11	8·8	sup.	20	18·5		31	4·1	sup.	10	13·6
	14	17·6	N.	24	3·3		June 3	12·9	N.	13	22·4
	18	2·4	inf.	27	12·1		6	21·7	inf.	17	7·1
	21	11·2	S.	30	20·9		10	6·5	S.		
	24	20·0	sup.	May 4	5·9		13	15·3	sup.		
	28	4·8	N.	7	14·5		17	0·9	N.		
	31	13·6	inf.	10	23·3		20	8·9	inf.		
Apr.	3	22·4	S.	14	8·1		23	17·7	S.		
	7	7·2	sup.	17	16·9		27	2·5	sup.		

Titania and *Oberon* will appear in opposite directions from the centre of the planet :—

		h			h			h
Feb.	28	23·7	Apr.	19	6·3	June	7	12·9
Mar.	25	15·0	May	13	21·6	July	2	4·3

and in the same direction :—

		h			h			h
Mar.	13	7·3	May	1	13·9	June	19	20·6
Apr.	6	22·6		26	5·2	July	14	11·9

Ephemeris for Physical Observations of Mars, 1890.   By A. Marth.

Greenwich Noon.	Angle of Position of ♂'s Axis.	Areographical Longit. | Latit. of Centre of Disc.		Apparent Diameter.	q	Q	E	Light-ratio.
1890. Feb. 25	36°58	183°03	+10°19	8″24	0″85	282°53	37°39	0·170
27	36·43	164·04	9·85	8·38	·86	282·20	37·32	·177
Mar. 1	36·28	145·07	+9·52	8·53	·87	281·88	37·24	0·184
3	36·13	126·12	9·20	8·69	·88	281·56	37·14	·191
5	35·97	107·18	8·88	8·85	·89	281·25	37·02	·199
7	35·81	88·26	8·57	9·02	·90	280·94	36·87	·207
9	35·64	69·36	8·27	9·19	·91	280·63	36·71	·216
11	35·48	50·48	7·98	9·37	·92	280·33	36·52	·225
13	35·31	31·62	7·69	9·56	·93	280·04	36·31	·235
15	35·14	12·77	7·41	9·75	·93	279·76	36·07	·246
17	34·97	353·95	7·15	9·94	·94	279·48	35·81	·257
19	34·80	335·15	6·90	10·14	·94	279·21	35·52	·269
21	34·64	316·38	6·65	10·35	·95	278·96	35·20	·281
23	34·48	297·63	6·42	10·56	·95	278·71	34·85	·294
25	34·32	278·90	6·21	10·78	·95	278·48	34·47	·308
27	34·17	260·20	6·01	11·01	·94	278·26	34·06	·323
29	34·02	241·52	5·82	11·24	·94	278·05	33·62	·338
31	33·88	222·88	5·65	11·48	·93	277·85	33·14	·355
Apr. 2	33·74	204·26	+5·49	11·73	·92	277·67	32·62	0·372
4	33·62	185·67	5·35	11·98	·91	277·51	32·07	·391
6	33·50	167·11	5·22	12·24	·90	277·37	31·48	·410
8	33·40	148·58	5·12	12·51	·89	277·25	30·85	·431
10	33·30	130·09	5·04	12·78	·87	277·15	30·18	·453
12	33·22	111·63	4·97	13·06	·85	277·07	29·46	·476
14	33·15	93·21	4·93	13·35	·82	277·01	28·70	·500
16	33·10	74·83	4·91	13·64	·79	276·98	27·89	·526
18	33·06	56·49	4·91	13·94	·76	276·98	27·03	·553
20	33·04	38·19	4·93	14·24	·73	277·01	26·12	·581
22	33·03	19·92	4·98	14·54	·69	277·08	25·16	·610
24	33·04	1·70	5·05	14·85	·65	277·18	24·15	·641
26	33·06	343·52	5·15	15·15	·61	277·31	23·09	·672
28	33·10	325·38	5·27	15·46	·56	277·49	21·97	·705
30	33·16	307·29	5·42	15·77	·51	277·72	20·80	·739
May 2	33·24	289·24	+5·59	16·08	·46	278·00	19·57	0·773
4	33·33	271·23	5·78	16·38	·41	278·34	18·29	·808

Titania.

	h			h			h				h	
Mar.	1	4·1	S.	Apr. 4	23·9		May 9	19·9	S.	June 13	15·8	
	3	8·3	sup.	7	4·2		12	0·1	sup.	15	20·1	
	5	12·5	N.	9	8·4		14	4·4	N.	18	0·3	
	7	16·8	inf.	11	12·7		16	8·6	inf.	20	4·5	
	9	21·0	S.	13	16·9		18	12·9	S.	22	8·8	
	12	1·3	sup.	15	21·2		20	17·1	sup.	24	13·0	
	14	5·5	N.	18	1·4		22	21·4	N.	26	17·3	
	16	9·7	inf.	20	5·7		25	1·6	inf.	28	21·5	
	18	14·0	S.	22	9·9		27	5·9	S.	July 1	1·7	
	20	18·2	sup.	24	14·2		29	10·1	sup.	3	6·0	
	22	22·5	N.	26	18·4		31	14·4	N.	5	10·2	
	25	2·7	inf.	28	22·7		June 2	18·6	inf.	7	14·5	
	27	7·0	S.	May 1	2·9		4	22·8	S.	9	18·7	
	29	11·2	sup.	3	7·2		7	3·1	sup.	11	22·9	
	31	15·5	N.	5	11·4		9	7·3	N. .	14	3·2	
Apr.	2	19·7	inf.	7	15·6		11	11·6	inf.	16	7·4	

Oberon.

	h			h			h				h	
Mar.	1	6·4	N.	Apr. 10	16·0		May 21	1·7	N.	June 30	11·2	
	4	15·2	inf.	14	0·9		24	10·5	inf.	July 3	20·0	
	8	0·0	S.	17	9·7		27	19·3	S.	7	4·8	
	11	8·8	sup.	20	18·5		31	4·1	sup.	10	13·6	
	14	17·6	N.	24	3·3		June 3	12·9	N.	13	22·4	
	18	2·4	inf.	27	12·1		6	21·7	inf.	17	7·1	
	21	11·2	S.	30	20·9		10	6·5	S.			
	24	20·0	sup.	May 4	5·9		13	15·3	sup.			
	28	4·8	N.	7	14·5		17	0·9	N.			
	31	13·6	inf.	10	23·3		20	8·9	inf.			
Apr.	3	22·4	S.	14	8·1		23	17·7	S.			
	7	7·2	sup.	17	16·9		27	2·5	sup.			

Titania and *Oberon* will appear in opposite directions from the centre of the planet :—

	h			h			h
Feb. 28	23·7		Apr. 19	6·3		June 7	12·9
Mar. 25	15·0		May 13	21·6		July 2	4·3

and in the same direction :—

	h			h			h
Mar. 13	7·3		May 1	13·9		June 19	20·6
Apr. 6	22·6		26	5·2		July 14	11·9

Ephemeris for Physical Observations of Mars, 1890. By A. Marth.

Greenwich Noon.	Angle of Position of ♂'s Axis.	Areographical Longit. | Latit. of Centre of Disc.		Apparent Dia-meter.	q	Q	E	Light-ratio.
1890.								
Feb. 25	36·58	183·03	+10·19	8·24	0·85	282·53	37·39	0·170
27	36·43	164·04	9·85	8·38	·86	282·20	37·32	·177
Mar. 1	36·28	145·07	+9·52	8·53	·87	281·88	37·24	0·184
3	36·13	126·12	9·20	8·69	·88	281·56	37·14	·191
5	35·97	107·18	8·88	8·85	·89	281·25	37·02	·199
7	35·81	88·26	8·57	9·02	·90	280·94	36·87	·207
9	35·64	69·36	8·27	9·19	·91	280·63	36·71	·216
11	35·48	50·48	7·98	9·37	·92	280·33	36·52	·225
13	35·31	31·62	7·69	9·56	·93	280·04	36·31	·235
15	35·14	12·77	7·41	9·75	·93	279·76	36·07	·246
17	34·97	353·95	7·15	9·94	·94	279·48	35·81	·257
19	34·80	335·15	6·90	10·14	·94	279·21	35·52	·269
21	34·64	316·38	6·65	10·35	·95	278·96	35·20	·281
23	34·48	297·63	6·42	10·56	·95	278·71	34·85	·294
25	34·32	278·90	6·21	10·78	·95	278·48	34·47	·308
27	34·17	260·20	6·01	11·01	·94	278·26	34·06	·323
29	34·02	241·52	5·82	11·24	·94	278·05	33·62	·338
31	33·88	222·88	5·65	11·48	·93	277·85	33·14	·355
Apr. 2	33·74	204·26	+5·49	11·73	·92	277·67	32·62	0·372
4	33·62	185·67	5·35	11·98	·91	277·51	32·07	·391
6	33·50	167·11	5·22	12·24	·90	277·37	31·48	·410
8	33·40	148·58	5·12	12·51	·89	277·25	30·85	·431
10	33·30	130·09	5·04	12·78	·87	277·15	30·18	·453
12	33·22	111·63	4·97	13·06	·85	277·07	29·46	·476
14	33·15	93·21	4·93	13·35	·82	277·01	28·70	·500
16	33·10	74·83	4·91	13·64	·79	276·98	27·89	·526
18	33·06	56·49	4·91	13·94	·76	276·98	27·03	·553
20	33·04	38·19	4·93	14·24	·73	277·01	26·12	·581
22	33·03	19·92	4·98	14·54	·69	277·08	25·16	·610
24	33·04	1·70	5·05	14·85	·65	277·18	24·15	·641
26	33·06	343·52	5·15	15·15	·61	277·31	23·09	·672
28	33·10	325·38	5·27	15·46	·56	277·49	21·97	·705
30	33·16	307·29	5·42	15·77	·51	277·72	20·80	·739
May 2	33·24	289·24	+5·59	16·08	·46	278·00	19·57	0·773
4	33·33	271·23	5·78	16·38	·41	278·34	18·29	·808

Grenwich Noon.	Angle of Position of ☾'s Axis.	Areographical Longit. of Centre of Disc.	Latit. of Centre of Disc.	Apparent Diameter.	q	Q	E	Light-ratio.
1890.	°	°		"	"	°	°	
May 6	33·44	253·27	+6·00	16·68	·36	278·76	16·96	0·844
8	33·56	235·35	6·25	16·97	·31	279·26	15·58	·880
10	33·70	217·47	6·51	17·25	·26	279·87	14·15	·915
12	33·85	199·62	6·80	17·53	·21	280·63	12·67	·950
14	34·01	181·82	7·11	17·79	·17	281·57	11·14	0·985
16	34·18	164·05	7·44	18·03	·13	282·80	9·57	1·018
18	34·37	146·32	7·79	18·26	·09	284·48	7·96	1·050
20	34·56	128·62	8·15	18·47	·06	286·94	6·33	1·080
22	34·76	110·94	8·52	18·66	·03	291·0	4·68	1·107
24	34·96	93·28	8·90	18·82	·01	299·3	3·05	1·132
26	35·16	75·63	9·28	18·96	·00	324·3	1·59	1·154
28	35·35	58·00	9·67	19·08	·00	37·6	1·34	1·172
30	35·55	40·37	10·06	19·17	·01	72·4	2·69	1·187
June 1	35·74	22·74	+10·45	19·24	·03	82·8	4·35	1·198
3	35·92	5·11	10·83	19·27	·05	87·62	6·06	1·205
5	36·10	347·47	11·20	19·28	·09	90·41	7·78	1·209
7	36·27	329·81	11·56	19·27	·13	92·30	9·50	1·208
9	36·42	312·14	11·90	19·23	·18	93·70	11·21	1·204
11	36·57	294·44	12·22	19·16	·24	94·79	12·89	1·196
13	36·70	276·70	12·53	19·07	·31	95·68	14·55	1·185
15	36·82	258·93	12·82	18·96	·38	96·43	16·17	1·171
17	36·93	241·13	13·08	18·83	·45	97·07	17·75	1·154
19	37·03	223·29	13·32	18·68	·52	97·62	19·29	1·134
21	37·12	205·40	13·54	18·51	·60	98·11	20·79	1·112
23	37·19	187·46	13·73	18·33	·68	98·54	22·24	1·088
25	37·25	169·48	13·89	18·13	·76	98·91	23·64	1·064
27	37·30	151·44	14·02	17·93	·84	99·24	24·98	1·039
29	37·34	133·35	14·13	17·71	·92	99·53	26·28	1·012
July 1	37·37	115·21	+14·21	17·49	0·99	99·78	27·52	0·985
3	37·38	97·02	14·27	17·26	1·06	99·99	28·71	·958
5	37·39	78·78	14·30	17·03	1·13	100·17	29·85	·930
7	37·39	60·48	14·30	16·79	1·19	100·32	30·94	·903
9	37·37	42·14	14·28	16·55	1·25	100·44	31·97	·876
11	37·35	23·75	14·23	16·31	1·31	100·53	32·96	·849
13	37·31	5·31	14·16	16·07	1·37	100·60	33·90	·823
15	37·27	346·82	14·06	15·83	1·42	100·64	34·79	·797
17	37·21	328·29	13·94	15·59	1·46	100·65	35·64	·772
19	37·14	309·71	13·80	15·36	1·50	100·64	36·44	·748

Greenwich Noon.	Angle of Position of ♂'s Axis.	Areographical Longit.	Latit. of Centre of Disc.		Apparent Diameter.	φ	Q	E	Light-ratio.
1890. July 21	37·06	291·09	+13·63		15˝12	1·54	100·61	37·20	0·724
23	36·97	272·43	13·44		14·89	1·57	100·55	37·91	·701
25	36·87	253·72	13·23		14·66	1·60	100·47	38·58	·679
27	36·75	234·98	13·01		14·44	1·63	100·37	39·22	·658
29	36·62	216·20	12·76		14·22	1·65	100·25	39·82	·638
31	36·48	197·39	12·49		14·00	1·67	100·10	40·39	·618
Aug. 2	36·32	178·55	+12·21		13·79	1·69	99·93	40·92	0·599
4	36·15	159·67	11·91		13·58	1·70	99·75	41·41	·581
6	35·96	140·76	11·59		13·38	1·71	99·55	41·88	·563
8	35·76	121·82	11·25		13·18	1·72	99·33	42·31	·546
10	35·54	102·85	10·90		12·98	1·72	99·09	42·71	·530
12	35·31	83·86	10·53		12·79	1·73	98·83	43·09	·515
14	35·06	64·84	10·15		12·61	1·73	98·56	43·44	·500
16	34·80	45·80	9·75		12·42	1·73	98·27	43·77	·486
18	34·51	26·74	9·34		12·24	1·72	97·96	44·07	·472
20	34·21	7·65	8·91		12·07	1·72	97·64	44·35	·459
22	33·89	348·54	8·17		11·90	1·71	97·30	44·60	·446
24	33·55	329·41	8·02		11·74	1·71	96·94	44·83	·434
26	33·19	310·26	7·56		11·58	1·70	96·56	45·05	·422
28	32·82	291·10	7·08		11·42	1·69	96·18 ·	45·24	·411
30	32·43	271·91	6·59		11·26	1·68	95·78	45·41	·400
Sept. 1	32·02	252·71	+6·10		11·11	1·67	95·37	45·57	0·390
3	31·59	233·49	5·59		10·96	1·66	94·95	45·71	·380
5	31·15	214·26	5·07		10·82	1·64	94·51	45·84	·371
7	30·69	195·01	4·54		10·68	1·63	94·06	45·95	·362
9	30·20	175·75	4·01		10·54	1·61	93·60	46·04	·353
11	29·69	156·48	3·47		10·41	1·60	93·12	46·12	·344
13	29·17	137·19	2·92		10·28	1·58	92·64	46·18	·336
15	28·63	117·89	2·36		10·15	1·56	92·15	46·23	·328
17	28·07	98·57	1·79		10·02	1·55	91·65	46·26	·320
19	27·50	79·24	1·22		9·90	1·53	91·14	46·28	·312
21	26·91	59·89	0·64		9·78	1·51	90·62	46·29	·305
23	26·30	40·54	+0·06		9·66	1·49	90·09	46·29	·298
25	25·67	21·17	−0·53		9·54	1·47	89·56	46·28	·292
27	25·03	1·79	1·12		9·43	1·46	89·02	46·26	·285
29	24·37	342·41	1·72		9·32	1·44	88·48	46·23	·279
Oct. 1	23·69	323·01	−2·32		9·21	1·42	87·93	46·18	0·273
3	23·00	303·59	2·93		9·11	1·40	87·38	46·13	·267

Greenwich Noon.	Angle of Position of ♂'s Axis.	Areographical Longit. | Latit. of Centre of Disc.		Apparent Diameter.	q	Q	E	Lightratio.
1890. Oct. 5	22·30	284·17	−3·53	9·00	1·38	86·82	46·07	0·261
7	21·58	264·74	4·14	8·90	1·36	86·27	46·00	·255
9	20·85	245·30	4·75	8·80	1·34	85·71	45·92	·250
11	20·10	225·84	5·36	8·70	1·32	85·15	45·83	·245
13	19·34	206·37	5·97	8·61	1·30	84·59	45·73	·240
15	18·57	186·89	6·59	8·51	1·28	84·02	45·63	·235
17	17·78	167·40	7·20	8·42	1·26	83·46	45·51	·230
19	16·99	147·90	7·81	8·33	1·24	82·91	45·39	·225
21	16·18	128·39	8·42	8·24	1·22	82·35	45·26	·220
23	15·37	108·87	9·02	8·15	1·20	81·80	45·13	·216
25	14·54	89·34	9·63	8·06	1·18	81·25	44·99	·211
27	13·71	69·79	10·23	7·98	1·16	80·70	44·84	·207
29	12·86	50·23	10·82	7·89	1·14	80·16	44·69	·203
31	12·01	30·67	−11·41	7·81	1·12	79·63	44·53	0·199

Q denotes the position-angle, and q the amount of the greatest defect of illumination, E the areocentric angle between Earth and Sun. The last column gives the ratio of the apparent brightness of *Mars* to that at mean opposition, the diminution of brightness due to the phase being assumed to depend simply on the proportion of the unilluminated portion to the whole of the disc.

The data of the ephemeris are founded upon the same elements as those for the oppositions of 1886 and 1888, and are to be interpolated directly for the times for which they are required, the equation of light having already been taken into account. The differences of successive values of the areographical longitude of the centre amount to one rotation and some 340 degrees, so that the greatest difference, at the end of May, is 702°·37, and the smallest, at the end of October, 700°·44.

The adopted zero-meridian will apparently pass the centre of the disc of *Mars* at the following Greenwich mean times :—

	h m		h m		h m
Feb. 25	12 7·1	Mar. 6	17 57·4	Mar. 15	23 46·2
26	12 46·1	7	18 36·3	17	0 24·9
27	13 25·1	8	19 15·1	18	1 3·5
28	14 4·0	9	19 53·9	19	1 42·1
Mar. 1	14 43·0	10	20 32·7	20	2 20·6
2	15 21·9	11	21 11·4	21	2 59·2
3	16 0·8	12	21 50·1	22	3 37·7
4	16 39·7	13	22 28·8	23	4 16·2
5	17 18·6	14	23 7·5	24	4 54·6

	h m			h m			h m
Mar. 25	5 33·1	May 5	6 41·0	June 15	6 54·5
26	6 11·5	6	7 17·8	16	7 31·0
27	6 49·9	7	7 54·6	17	8 7·5
28	7 28·2	8	8 31·3	18	8 44·1
29	8 6·5	9	9 8·0	19	9 20·8
30	8 44·8	10	9 44·6	20	9 57·5
31	9 23·1	11	10 21·2	21	10 34·2
Apr. 1	10 1·3	12	10 57·8	22	11 11·0
2	10 39·5	13	11 34·3	23	11 47·8
3	11 17·7	14	12 10·8	24	12 24·7
4	11 55·8	15	12 47·2	25	13 1·6
5	12 33·9	16	13 23·6	26	13 38·6
6	13 12·0	17	14 0·0	27	14 15·7
7	13 50·0	18	14 36·3	28	14 52·8
8	14 28·0	19	15 12·6	29	15 30·0
9	15 5·9	20	15 48·8	30	16 7·2
10	15 43·8	21	16 25·1	July 1	16 44·5
11	16 21·7	22	17 1·3	2	17 21·9
12	16 59·6	23	17 37·5	3	17 59·3
13	17 37·4	24	18 13·7	4	18 36·7
14	18 15·1	25	18 49·9	5	19 14·2
15	18 52·8	26	19 26·0	6	19 51·8
16	19 30·5	27	20 2·2	7	20 29·4
17	20 8·1	28	20 38·3	8	21 7·0
18	20 45·7	29	21 14·5	9	21 44·7
19	21 23·3	30	22 50·6	10	22 22·5
20	22 0·8	31	22 26·8	11	23 0·3
21	22 38·3	June 1	23 2·9	12	23 38·2
22	23 15·7	2	23 39·0	14	0 16·1
23	23 53·0	4	0 15·2	15	0 54·1
25	0 30·3	5	0 51·4	16	1 32·1
26	1 7·6	6	1 27·6	17	2 10·2
27	1 44·8	7	2 3·8	18	2 48·3
28	2 22·0	8	2 40·0	19	3 26·5
29	2 59·2	9	3 16·3	20	4 4·7
30	3 36·3	10	3 52·6	21	4 43·0
May 1	4 13·3	11	4 28·9	22	5 21·3
2	4 50·3	12	5 5·2	23	5 59·6
3	5 27·3	13	5 41·6	24	6 38·0
4	6 4·2	14	6 18·0	25	7 16·4

	h m		h m		h m
July 26	7 54·9	Aug. 28	4 43·2	Sept. 30	1 52·2
27	8 33·4	29	5 22·6	Oct. 1	2 32·1
28	9 12·0	30	6 2·0	2	3 12·0
29	9 50·6	31	6 41·4	3	3 51·9
30	10 29·2	Sept. 1	7 20·9	4	4 31·8
31	11 7·9	2	8 0·4	5	5 11·7
Aug. 1	11 46·6	3	8 39·9	6	5 51·7
2	12 25·3	4	9 19·4	7	6 31·6
3	13 4·1	5	9 59·0	8	7 11·6
4	13 42·9	6	10 38·5	9	7 51·6
5	14 21·7	7	11 18·1	10	8 31·6
6	15 0·6	8	11 57·7	11	9 11·6
7	15 39·5	9	12 37·3	12	9 51·6
8	16 18·5	10	13 16·9	13	10 31·6
9	16 57·5	11	13 56·5	14	11 11·6
10	17 36·5	12	14 36·1	15	11 51·7
11	18 15·5	13	15 15·8	16	12 31·8
12	18 54·5	14	15 55·5	17	13 11·8
13	19 33·6	15	16 35·2	18	13 51·9
14	20 12·7	16	17 14·9	19	14 32·0
15	20 51·8	17	17 54·6	20	15 12·1
16	21 30·9	18	18 34·3	21	15 52·2
17	22 10·1	19	19 14·0	22	16 32·4
18	22 49·3	20	19 53·8	23	17 12·5
19	23 28·6	21	20 33·6	24	17 52·7
21	0 7·8	22	21 13·4	25	18 32·0
22	0 47·1	23	21 53·2	26	19 13·0
23	1 26·4	24	22 33·0	27	19 53·0
24	2 5·7	25	23 12·8	28	20 33·5
25	2 45·0	26	23 52·6	29	21 13·7
26	3 24·4	28	0 32·5	30	21 53·9
27	4 3·8	29	1 12·3	31	22 34·1

Ephemeris of the Satellites of Mars, 1890.   By A. Marth.

Greenwich Noon.	P	a_1	b_1	u_1-U	a_2	b_2	u_2-U	U	B
			Phobos.			Deimos.			
1890.	°			°				°	
Apr. 14	33·29	18″45 + 1″85		343·23	46″19 + 4″65		234·09	210·09 + 5·78	
16	33·24	18·86	1·89	80·81	47·19	4·73	84·24	210·29	5·76
18	33·20	19·27	1·93	178·44	48·21	4·84	294·43	210·45	5·76
20	33·18	19·68	1·98	276·11	49·25	4·96	144·66	210·57	5·78
22	33·17	20·10	2·04	13·81	50·30	5·11	354·94	210·64	5·83
24	33·18	20·52	2·11	111·55	51·36	5·28	205·25	210·67	5·90
26	33·20	20·95	2·19	209·33	52·43	5·48	55·61	210·66	6·00
28	33·24	21·38	2·28	307·15	53·50	5·71	266·01	210·61	6·12
30	33·30	21·80	2·38	45·02	54·56	5·96	116·45	210·51	6·27
May 2	33·37	22·23 + 2·49		142·93	55·62 + 6·24		326·93	210·37 + 6·44	
4	33·46	22·65	2·62	240·87	56·67	6·55	177·46	210·18	6·63
6	33·56	23·06	2·76	338·85	57·71	6·89	28·03	209·95	6·85
8	33·68	23·46	2·90	·76·88	58·72	7·26	238·65	209·67	7·10
10	33·81	23·85	3·06	174·95	59·70	7·66	89·31	209·36	7·37
12	33·96	24·23	3·23	273·05	60·64	8·08	300·00	209·00	7·66
14	34·12	24·59	3·41	11·19	61·54	8·53	150·74	208·60	7·97
16	34·29	24·93	3·60	109·36	62·39	9·00	· 1·51	208·17	8·30
18	34·47	25·25	3·80	207·56	63·18	9·49	212·31	207·70	8·64
20	34·65	25·54	4·00	305·79	63·90	10·00	63·14	207·20	9·00
22	34·84	25·80	4·20	44·04	64·55	10·52	274·00	206·68	9·38
24	35·03	26·03	4·41	142·30	65·13	11·04	124·88	206·13	9·76
26	35·22	26·22	4·62	240·58	65·62	11·56	335·78	205·56	10·14
28	35·41	26·38	4·82	338·86	66·02	12·07	186·69	204·98	10·53
30	35·60	26·51	5·02	77·15	66·33	12·57	37·60	204·40	10·92
June 1	35·78	26·60 + 5·21		175·44	66·55 + 13·05		248·51	203·81 + 11·31	
3	35·95	26·65	5·40	273·72	66·68	13·51	99·42	203·23	11·69
5	36·12	26·66	5·57	11·98	66·72	13·94	310·32	202·65	12·06
7	36·28	26·64	5·73	110·23	66·67	14·33	161·21	202·09	12·42
9	36·43	26·58	5·87	208·45	66·53	14·69	12·07	201·55	12·76
11	36·57	26·49	6·00	306·65	66·30	15·01	222·91	201·03	13·09
13	36·69	26·37	6·11	44·82	65·99	15·29	73·72	200·54	13·39
15	36·81	26·21	6·20	142·94	65·60	15·52	284·50	200·08	13·68
17	36·91	26·03	6·27	241·03	65·14	15·70	135·24	199·66	13·95
19	37·00	25·82	6·33	339·07	64·62	15·84	345·94	199·28	14·19
21	37·08	25·59	6·36	77·07	64·04	15·93	196·59	198·94	14·40

Greenwich Noon.	P	Phobos.			Deimos.			U	B
		a_1	b_1	$u_1 - U$	a_2	b_2	$u_2 - U$		
1890. June 23	37.15	25.34 + 6.38		175.02	63.41 + 15.97		47.19	198.65 + 14.59	
25	37.21	25.07	6.38	272.91	62.74	15.97	257.75	198.41	14.75
27	37.25	24.79	6.37	10.75	62.03	15.93	108.26	198.22	14.88
29	37.29	24.49	6.34	108.54	61.28	15.85	318.71	198.08	14.99
July 1	37.32	24.18 + 6.29		206.28	60.51 + 15.74		169.12	197.99 + 15.07	
3	37.33	23.86	6.23	303.96	59.72	15.59	19.47	197.95	15.13
5	37.34	23.54	6.16	41.59	58.91	15.40	229.77	197.96	15.16
7	37.34	23.21	6.07	139.17	58.09	15.19	80.02	198.02	15.16
9	37.32	22.88	5.97	236.70	57.27	14.95	290.22	198.13	15.14
11	37.30	22.55	5.87	334.17	56.44	14.69	140.37	198.29	15.09
13	37.27	22.22	5.76	71.59	55.61	14.41	350.47	198.50	15.02
15	37.23	21.89	5.64	168.97	54.78	14.10	200.53	198.76	14.92
17	37.18	21.56 + 5.51		266.30	53.95 + 13.78		50.54	199.06 + 14.80	
19	37.11	21.23	5.37	3.58	53.13	13.44	260.50	199.40	14.66
21	37.03	20.91	5.23	100.82	52.32	13.09	110.42	199.79	14.49
23	36.95	20.59	5.09	198.02	51.52	12.73	320.30	200.22	14.30
25	36.86	20.27	4.94	295.18	50.73	12.35	170.14	200.69	14.10
27	36.75	19.96	4.78	32.29	49.95	11.97	19.94	201.20	13.87
29	36.63	19.66	4.63	129.37	49.19	11.58	229.70	201.74	13.62
31	36.49	19.36	4.47	226.42	48.45	11.19	79.43	202.32	13.35
Aug. 2	36.34	19.07 + 4.31		323.43	47.71 + 10.79		288.13	202.93 + 13.07	
4	36.18	18.78	4.15	60.40	46.99	10.39	138.79	203.58	12.77
6	36.01	18.50	3.99	157.35	46.29	9.98	348.42	203.25	12.45
8	35.82	18.22	3.82	254.27	45.60	9.57	198.03	204.95	12.11
10	35.61	17.95	3.66	351.16	44.92	9.16	47.61	205.68	11.76
12	35.39	17.69	3.49	88.02	44.26	8.74	257.16	206.44	11.39
14	35.15	17.43	3.33	184.86	43.61	8.33	106.69	207.22	11.01
16	34.90	17.18 + 3.16		281.67	42.98 + 7.91		316.19	208.02 + 10.61	

In this ephemeris the two satellites are assumed to move in a plane, the node N and inclination J of which, in reference to the plane parallel to the Earth's equator, are :—

$$N = 49°.563 ; \quad J = 36°.021.$$

The assumed orbital longitudes, reckoned from the node, are :—

$$\text{Phobos } u_1 = 22°.41 + 1128°.8445 \ (t - t_0)$$
$$\text{Deimos } u_2 = 93°.12 + 285°.1622 \ (t - t_0)$$

the epoch t_0 being 1890, June, 1.0 Gr.

The values of P, a, b, $u - U$ are to be interpolated directly for the times for which the positions of the satellites are required, and the position-angles p and distances s are then found by means of the formulæ :—

$$s \sin (p - P) = a \sin (u - U)$$
$$s \cos (p - P) = b \cos (u - U).$$

Greenwich times, at which the satellites will be at their greatest elongations (e in position $P + 90°$ and w in position $P - 90°$), the designation, in the case of *Phobos*, belonging to both given times, so that an elongation on the opposite side occurs at mid-time between them :—

1890.	Phobos h		h	Deimos h	1890.	Phobos h		h	Deimos h
Apr. 14	17·6	e	25·2	18·2 e	May 12	11·4	e	19·1	12·6 e
15	16·5	e	24·2	24·5 e	13	14·2	w	21·8	18·9 e
16	15·5	e	23·2	15·6 w	14	13·2	w	20·8	10·0 w
17	14·5	e	22·1	21·9 w	15	12·1	w	19·8	16·3 w
18	13·4	e	21·1	13·1 e	16	11·1	w	18·7	22·6 w
19	12·4	e	20·0	19·4 e	17	13·8	e	21·5	13·7 e
20	15·2	w	22·8	25·7 e	18	12·8	e	20·5	20·0 e
21	14·1	w	21·8	16·8 w	19	11·8	e	19·4	11·1 w
22	13·1	w	20·8	23·1 w	20	10·7	e	18·4	17·4 w
23	15·9	e	23·5	14·3 e	21	13·5	w	21·1	23·7 w
24	14·9	e	22·5	20·6 e	22	12·5	w	20·1	15·3 e
25	13·8	e	21·5	11·7 w	23	11·4	w	19·1	21·1 e
26	12·8	e	20·4	18·0 w	24	10·4	w	18·0	12·2 w
27	11·7	e	19·4	24·3 w	25	13·1	e	20·8	18·5 w
28	14·5	w	22·2	15·5 e	26	12·1	e	19·7	9·6 e
29	13·5	w	21·1	21·8 e	27	11·1	e	18·7	15·9 e
30	12·4	w	20·1	12·9 w	28	10·0	e	17·7	22·1 e
May 1	15·2	e	22·9	19·2 w	29	12·8	w	20·4	13·3 w
2	14·2	e	21·8	10·3 e	30	11·7	w	19·4	19·5 w
3	13·1	e	20·8	16·6 e	31	10·7	w	18·4	10·7 e
4	12·1	e	19·7	22·9 e	June 1	9·7	w	17·3	16·9 e
5	14·9	w	22·5	14·1 w	2	12·4	e	20·1	8·1 w
6	13·8	w	21·5	20·3 w	3	11·4	e	19·0	14·3 w
7	12·8	w	20·4	11·5 e	4	10·3	e	18·0	20·6 w
8	11·7	w	19·4	17·8 e	5	9·3	e	17·0	11·7 e
9	14·5	e	22·2	8·9 w	6	12·1	w	19·7	18·0 e
10	13·5	e	21·1	15·2 w	7	11·0	w	18·7	9·1 w
11	12·4	e	20·1	21·5 w	8	10·0	w	17·6	15·4 w

1890.	Phobos.		Deimos.	1890.	Phobos.		Deimos.
	h		h	h		h		h	h
June 9	12·8 e	20·4	21·7 w	July 11	10·1 e	17·8	10·9 w
10	11·7 e	19·4	12·8 e	12	9·1 e	16·7	17·2 w
11	10·7 e	18·3	19·1 e	13	8·0 e	15·7	8·4 e
12	9·6 e	17·3	10·2 w	14	10·8 w	18·5	14·7 e
13	12·4 w	20·1	16·5 w	15	9·8 w	17·5	5·8 w
14	11·4 w	19·0	7·6 e	16	8·8 w	16·4	12·2 w
15	10·4 w	18·0	13·9 e	17	11·6 e	19·2	18·5 w
16	9·3 w	17·0	20·2 e	18	10·5 e	18·2	9·6 e
17	8·3 w	15·9	11·3 w	19	9·5 e	17·1	16·0 e
18	11·1 e	18·7	17·6 w	20	8·5 e	16·1	7·1 w
19	10·0 e	17·7	8·7 e	21	7·4 e	15·1	13·4 w
20	9·0 e	16·6	15·0 e	22	10·2 w	17·9	19·8 w
21	11·7 w	19·4	21·3 e	23	9·2 w	16·8	10·9 e
22	10·7 w	18·4	12·5 w	24	8·1 w	15·8	17·2 e
23	9·7 w	17·3	18·7 w	25	7·1 w	14·8	8·4 w
24	8·6 w	16·3·	9·9 e	26	9·9 e	17·6	14·7 w
25	11·4 e	19·1	16·2 e	27	8·9 e	16·5	5·9 e
26	10·4 e	18·0	7·3 w	28	7·8 e	15·5	12·2 e
27	9·3 e	17·0	13·6 w	29	10·6 w	18·3	18·6 e
28	8·3 e	15·9	19·9 w	30	9·6 w	17·3	9·7 w
29	11·1 w	18·7	11·0 e	31	8·6 w	16·2	16·1 w
30	10·0 w	17·7	17·3 e	Aug. 1	7·5 w	15·2	7·2 e
July 1	9·0 w	16·7	8·5 w	2	10·3 e	18·0	13·6 e
2	8·0 w	15·6	14·8 w	3	9·3 e	17·0	19·9 e
3	10·8 e	18·4	5·9 e	4	8·3 e	15·9	11·1 w
4	9·7 e	17·4	12·2 e	5	7·3 e	14·9	17·4 w
5	8·7 e	16·3	18·5 e	6	10·0 w	17·7	8·6 e
6	11·5 w	19·1	9·7 w	7	9·0 w	16·7	14·9 e
7	10·4 w	18·1	16·0 w	8	8·0 w	15·6	6·1 w
8	9·4 w	17·0	7·1 e	9	7·0 w	14·6	12·4 w
9	8·4 w	16·0	13·4 e	10	9·8 e	17·4	18·7 w
10	11·2 e	18·8	19·8 e	11	8·7 e	16·4	9·9 e

If the assumed plane of the orbits does not differ too much from their true planes, this year's cycle of eclipses of *Phobos* will last from about March 19 to October 9, that of *Deimos* from June 2 to August 9, the central eclipses occurring about July 7. The earliest eclipses of *Deimos* will not be observable, but a week after the beginning of the cycle the satellite will be at its disappearance more than half a semi-diameter of the planet's disc outside the disc. In order to induce observers to watch duly for the disappearances and reappearances of the satellite, I give

approximate Greenwich times of the middle of the eclipses and of their semi-duration, it being understood that these predictions may be sensibly in error. It will be of special importance to observe the latest eclipses of the cycle, the duration of which is very uncertain.

Eclipses of Deimos.

	Middle. h m	Semi-dur. m		Middle. h m	Semi-dur. m		Middle. h m	Semi-dur. m
June 8	23 47	24	June 30	11 47	40	July 24	12 31	35
11	12 29	27	July 1	18 8	40	25	18 53	34
12	18 50	29	5	13 12	41	28	7 36	31
15	7 32	32	6	19 33	41	29	13 57	30
16	13 54	33	9	8 16	41	30	20 19	28
17	20 15	34	10	14 37	41	Aug. 2	9 1	24
20	8 57	36	11	20 58	41	3	15 23	22
21	15 18	37	14	9 41	40	7	10 27	? 12
22	21 39	38	15	16 2	40	8	16 49	? 8
25	10 22	39	19	11 6	38	12	11 54	?
26	16 43	39	20	17 27	38	13	18 15	?

The disappearances of *Phobos* into the planet's shadow will not be observable, and I give therefore approximate Greenwich times of its reappearances, the error of which, though it may be very sensible, will probably not vary much.

Eclipses of Phobos. Reappearances.

	h m	h m		h m	h m		h m	h m
June 15	13 0	20 39	July 5	7 46	15 26	July 25	10 11	17 51
16	11 58	19 38	6	14 24	22 4	26	9 10	16 49
17	10 57	18 36	7	13 22	21 2	27	8 8	15 48
18	9 55	17 34	8	12 21	20 0	28	7 6	14 46
19	8 43	16 23	9	11 19	18 58	29	6 4	13 44
20	15 31	23 10	10	10 18	17 57	30	5 3	12 42
21	14 29	22 9	11	9 16	16 55	31	11 40	19 20
22	13 27	21 7	12	8 14	15 54	Aug. 1	10 38	18 18
23	12 26	20 5	13	7 12	14 52	2	9 37	17 16
24	11 24	19 4	14	6 10	13 50	3	8 35	16 15
25	10 23	18 2	15	12 48	20 28	4	7 34	15 13
26	9 22	17 1	16	11 47	19 26	5	6 32	14 11
27	8 21	16 0	17	10 45	18 25	6	5 30	13 9
28	7 19	14 58	18	9 44	17 23	7	12 8	19 47
29	14 6	21 36	19	8 42	16 21	8	11 6	18 46
30	12 55	20 34	20	7 40	15 20	9	10 5	17 44
July 1	11 53	19 32	21	6 38	14 18	10	9 3	16 42
2	10 51	18 30	22	5 37	13 16	11	8 1	15 40
3	9 50	17 29	23	12 15	19 54	12	7 0	14 39
4	8 48	16 28	24	11 13	18 52	13	5 58	13 37

During the period for which these ephemerides of the satellites are given, the light-ratio (to be found in the preceding ephemeris for physical observations of the planet) is at least one half of that at mean opposition. It would not be worth the trouble to extend micrometrical measurements beyond or even up to the limits of this period. But, as it would be of essential service for the determination of the true planes of the orbits (and thereby for the future determination of the ellipticity of the planet) if observations of some of the earliest and latest eclipses of all cycles, which render such observations feasible, were secured, I venture to give the necessary predictions for the earliest eclipses of *Phobos*, though the light-ratio is only about a quarter of that at mean opposition, and though it is doubtful whether the apparent nearness of the satellite to the limb of the planet at its reappearances from the shadow will not prevent its being seen. The oppositions of *Phobos* to the Sun occur about the following Greenwich times :—

	h m	h m		h m	h m		h m	h m
Mar. 16	14 20	21 59	Mar. 20	17 52	25 31	Mar. 24	13 45	21 24
17	13 18	20 57	21	16 50	24 29	25	20 22	...
18	12 16	19 56	22	15 48	23 27	26	19 21	...
19	18 54	...	23	14 46	22 25	27	18 19	25 58

About $1^{h}\cdot 2$ before these times *Phobos* will be at its apparent greatest western elongations. But the apparent positions of both satellites may be found with the help of the following ephemeris, in which the values a, b of the semi-axes of the apparent ellipses are expressed, not in seconds of arc, but in semi-diameters of the planet's disc.

Greenwich Noon.	P		*Phobos.*			*Deimos.*	
		a_1	b_1	$u_1 - U$	a_2	b_2	$u_2 - U$
Mar. 17	35°·06	2″·765	+0″·391	60°·35	6″·920	+0″·980	175°·55
19	34·90		·379	157·55		·949	25·28
21	34·75		·368	254·76		·920	235·04
23	34·60		·357	351·99		·892	84·82
25	34·45	2·765	+0·346	89·25	6·920	+0·866	294·62

If observers will be good enough to publish or communicate in time the results of their endeavours to observe the first eclipses of *Phobos*, I intend to give the prediction for the rest of the cycle, in case that appears desirable.

Note.

Mr. Levander's paper on " The Colours of Stars," on page 33, was printed in abstract; a table, showing the 95 tints observed in the 4984 stars previously mentioned, not being printed.

W. H. M. Christie, M.A., F.R.S., President, in the Chair.

James Blair Forgan, 15 Pall Mall, S.W.;
Richard A. Gregory, Science Schools, South Kensington, and 115 Rylston Road, Fulham, S.W. ;
Alfred Newton Harris, 21 Lambhay Street, Plymouth ;
Frederick William Henkel, jun., 32 Berwick Road, Walthamstow,

were balloted for and duly elected Fellows of the Society.

The following candidates were proposed for election, the names of the proposers from personal knowledge being appended :—

Sir George Errington, Lackham Manor, and Brooks's Club (proposed by the Earl of Crawford, and Baron de Worms);
Edward Robinson, 4 Castelnau Gardens, Barnes, S.W. (proposed by A. Cowper Ranyard);
Andrew Simons, H.M. Dockyard Schools, Devonport (proposed by T. Archer Hirst).

Report of the Council to the Seventieth Annual General Meeting of the Society.

The following table shows the progress and present state of the Society :—

	Compounders	Annual Subscribers	Mathematical Society	Total Fellows	Associates	Patron	Grand Total
December 31, 1888	230	360	3	593	47	1	641
Since elected	+ 8	+ 16	...	...	+ 4	...	...
Deceased	− 7	− 6	...	...	− 3	...	...
Resigned	...	− 7	...	...	...	...	...
Expelled	...	− 2	...	...	...	...	...
Removals	+ 3	− 3	...	...	...	...	...
December 31, 1889	234	358	3	595	48	1	644

Mr. Common's Account as Treasurer of the Royal

RECEIPTS.

	£	s.	d.	£	s.	d.
Balances, January 1, 1889:—						
at Bankers', as per pass book	345	19	8			
„ on Deposit Account	300	0	0			
in hand of Assistant Secretary on account						
of Turnor and Horrox Fund	0	14	10			
in hand of Assistant Secretary on Petty						
Cash Account	4	15	5			
				651	9	11
Dividends on £13,200 Consols	370	0	6			
„ £750 Metropolitan Stock	21	19	0			
				391	19	6
Received on account of Subscriptions :—						
Arrears	129	3	0			
238 Annual Contributions for 1889	499	16	0			
3 „ „ 1890	6	6	0			
23 Admission Fees	48	6	0			
17 First Contributions	26	5	0			
				709	16	0
10 Composition Fees				210	0	0
Sales of Publications :—						
At Williams and Norgate's, 1888	36	7	1			
At Society's Rooms, 1889	39	0	3			
				75	7	4

Audited and found correct 1890 Jan. 8.

W. B. GIBBS.
ROBT. J. LECKY,
EDWD. W. MAUNDER.

£2,038 12 9

Astronomical Society, from January 1 to December 31, 1889.

EXPENDITURE.

	£	s.	d.	£	s.	d.
Assistant Secretary : Salary	250	0	0			
„ „ for assistance in editing Society's Publications ...	50	0	0			
				3co	0	0
Income Tax and House Duty	10	10	0			
Fire Insurance	7	16	6			
				18	6	6
Printing, &c.	325	18	0			
Lithography and Engraving	24	0	6			
				349	18	6
Computation of Ephemerides	50	0	0			
Lunar Computations	10	18	6			
				60	18	6
Turnor and Horrox Fund : purchases for Library	15	1	5			
Binding Books in Library	22	19	11			
				38	1	4
House Expenses	31	6	4			
Wages	32	14	0			
Postage, &c.	60	4	10			
Carriage of Parcels	2	8	10			
Stationery and Office Expenses	8	7	11			
Expenses of Meetings	22	2	0			
Fittings and Repairs	7	17	3			
Coals and Gas	59	3	9			
Electric Lighting Expenses	8	13	10			
Time Signal : Rental of Wire	5	0	0			
Assistance rearranging Books, &c.	4	15	6			
Advertising	1	19	6			
Sundries	7	16	5			
				252	10	2
Mrs. Jackson Gwilt's Annuity				8	19	0
Lee and Janson Fund Grants				10	0	0
Bankers' Deductions on Cheques, &c.				0	2	3
Balances, December 31, 1889 :—						
at Bankers', as per pass book	488	18	7			
„ on Deposit Account	500	0	0			
in hand of Assistant Secretary on account of Turnor and Horrox Fund	4	13	5			
in hand of Assistant Secretary on Petty Cash Account	6	4	6			
				999	16	6
				£2.038	12	9

Assets and Present Property of the Society, January 1, 1890.

	£	s.	d.	£	s.	d.
Balances, December 31, 1889:—						
At Bankers', as per Pass Book	488	18	7			
„ on Deposit Account	500	0	0			
In hand of Assistant Secretary on account of Turnor and Horrox Fund	4	13	5			
In hand of Assistant Secretary on Petty Cash Account	6	4	6			
				999	16	6
Due on account of Subscriptions :—						
1 Contribution of 4 years' standing	8	8	0			
12 Contributions of 3 „	75	12	0			
34 „ 2 „	142	16	0			
83 „ 1 year's standing ...	174	6	0			
2 Admission Fees and 1st Subscriptions	6	6	0			
	407	8	0			
Less 3 Contributions paid in advance ...	6	6	0			
				401	2	0
Due from Messrs. Williams and Norgate for sales of Publications during 1889				22	19	0

£7,500 2¾ per Cent. Consols, including the Lee and Janson Fund, and the Turnor and Horrox Memorial Funds.

£5,700 2½ per Cent. Consols, including Mrs. Jackson Gwilt's gift (£300).

£750 Metropolitan 3 per Cent. Stock.

Astronomical and other Manuscripts, Books, Prints, Instruments, and Furniture.

Unsold Publications of the Society.

Report of the Auditors.

   We have examined the Treasurer's accounts, and have found
and certified the same to be correct.   The cash in hand on Dec.
31, 1889, including the balance at the bankers', and a sum of
500l. on deposit, amounted to 999l. 16s. 6d.

   The funded property of the Society is the same as at the end
of last year.

   The books, instruments, and other effects have been examined,
and they appear to be in a satisfactory condition.

   We have laid on the table a list of the names of those
Fellows who are in arrear for sums due at the last Annual
General Meeting, with the amount due against each Fellow's
name.

                    (Signed)   W. B. GIBBS,
                               ROBT. J. LECKY,
                               EDWD. W. MAUNDER.

Stock in hand of volumes of the *Memoirs* :—

Vol.	At Society's Rooms	At Williams & Norgate's	Vol.	At Society's Rooms	At Williams & Norgate's
I. Part 1	7	...	XXIX.	406	...
I. Part 2	35	...	XXX.	159	1
II. Part 1	55	...	XXXI.	142	...
II. Part 2	20	...	XXXII.	154	1
III. Part 1	63	1	XXXIII.	163	...
III. Part 2	85	1	XXXIV.	164	4
IV. Part 1	78	3	XXXV.	108	5
IV. Part 2	91	3	XXXVI.	196	8
V.	105	3	XXXVII. Part 1	336	8
VI.	124	3	XXXVII. Part 2	285	8
VII.	148	3	XXXVIII.	271	...
VIII.	127	3	XXXIX. Part 1	242	4
IX.	134	3	XXXIX. Part 2	246	3
X.	140	...	XL.	243	...
XI.	153	...	XLI.	412	...
XII.	159	...	XLII.	233	3
XIII.	163	...	XLIII.	235	1
XIV.	367	2	XLIV.	217	...
XV.	140	...	XLV.	248	1
XVI.	165	...	XLVI.	234	2
XVII.	147	1	XLVII. Part 1	3	...
XVIII.	141	...	XLVII. Part 2	18	...
XIX.	148	...	XLVII. Part 3	2	...
XX.	142	...	XLVII. Part 4	10	...
XXI. Part 1	308	...	XLVII. Part 5	10	...
XXI. Part 2	98	...	XLVII. Part 6	10	...
XXI. 1 & 2 (together)	61	...	XLVII.	216	2
XXII.	164	...	XLVIII. Part 1	261	3
XXIII.	150	...	XLVIII. Part 2	272	1
XXIV.	156	...	XLIX. Part 1	537	...
XXV.	166	...			
XXVI.	172	...	Index to Memoirs }	644	1
XXVII.	424	...			
XXVIII.	382	...			

Stock in hand of volumes of the *Monthly Notices* :—

Vol.	At Society's Rooms	At Williams & Norgate's	Vol.	At Society's Rooms	At Williams & Norgate's
I.	65	...	XXVI.	11	...
II.	67	...	XXVII.	4	...
III.	...	...	XXVIII.	73	...
IV.	...	...	XXIX.	53	...
V.	...	...	XXX.	66	2
VI.	52	...	XXXI.	94	...
VII.	2	...	XXXII.	117	5
VIII.	154	2	XXXIII.	98	2
IX.	24	3	XXXIV.	77	2
X.	180	1	XXXV.	58	1
XI.	185	1	XXXVI.	32	1
XII.	109	2	XXXVII.	44	3
XIII.	178	3	XXXVIII.	97	2
XIV.	178	3	XXXIX.	102	1
XV.	170	2	XL.	113	3
XVI.	155	2	XLI.	113	5
XVII.	167	1	XLII.	122	1
XVIII.	246	...	XLIII.	122	1
XIX.	58	...	XLIV.	125	...
XX.	34	...	XLV.	125	3
XXI.	17	...	XLVI.	119	3
XXII.	33	...	XLVII.	127	5
XXIII.	19	...	XLVIII.	129	6
XXIV.	24 '	...	XLIX.	149	...
XXV.	15	...	Index ...	565	1

LIBRARY CATALOGUE   ...   . 606 .

In addition to the above volumes of the *Monthly Notices*, the Society has a considerable stock of separate numbers of nearly all the volumes. With the exception, however, of Vols. XXXVI. to XLIX. no complete volumes can be formed from the separate numbers in stock.

Instruments belonging to the Society.

No. 1. The *Harrison* clock.

„ 2. The *Owen* portable circles, by Jones.

„ 3. The *Beaufoy* circle.

No. 4. The *Beaufoy* transit instrument.

,, 5. The *Herschel* 7-foot telescope.

,, 6. The *Greig* universal instrument, by Reichenbach and Ertel. The transit telescope, by Utzschneider and Fraunhofer, of Munich.

,, 7. The *Smeaton* equatoreal

,, 8. The *Cavendish* apparatus.

,, 9. The 7-foot Gregorian telescope (late Mr. Shearman's).

,, 10. The variation transit instrument (late Mr. Shearman's).

,, 11. The universal quadrat, by Abraham Sharp.

,, 12. The *Fuller* theodolite.

,, 13. The standard scale, by Troughton and Simms.

,, 14. The *Beaufoy* clock, No. 1.

,, 15. The *Beaufoy* clock, No. 2.

,, 16. The *Wollaston* telescope.

,, 17. The *Lee* circle.

,, 18. The *Sharpe* reflecting circle.

,, 19. The *Brisbane* circle.

,, 20. The *Baker* universal equatoreal.

,, 21. The *Reade* transit.

,, 22. The *Matthew* equatoreal, by Cooke.

,, 23. The *Matthew* transit instrument.

,, 24. The *South* transit instrument.

,, 25. A sextant, by Bird (formerly belonging to Captain Cook).

,, 26. A globe showing the precession of the equinoxes.

The *Sheepshanks* collection : —

,, 27. (1) 30-inch transit instrument, by Simms, with level and two iron stands.

,, 28. (2) 6-inch transit theodolite, with circles divided on silver; reading microscopes, both for altitude and azimuth ; cross and siding levels; magnetic needle; plumbline; portable clamping foot and tripod stand.

,, 29. (3) Equatoreal stand and clock movement for $4\frac{6}{10}$-inch telescope (telescope lost) ; double-image micrometer; two wire micrometers; object-glass micrometer.

,, 30. (4) $3\frac{1}{4}$-inch achromatic telescope, with equatoreal stand; double-image micrometer; one terrestrial and three astronomical eyepieces.

,, 31. (5) $2\frac{1}{4}$-inch achromatic telescope, with stand; one terrestrial and three astronomical eyepieces.

,, 33. (7) 2 foot navy telescope.

,, 34. (8) Transit instrument of 45 inches focal length, with iron stand and also Ys for fixing to stone piers; two axis levels.

,, 35. (9) Repeating theodolite, by Ertel, with folding tripod stand.

,, 36. (10) 8-inch pillar sextant, by Troughton, divided

on platinum, with counterpoise stand and artificial horizon.

No. 37. (11) Portable zenith telescope and stand, $2\frac{3}{4}$-inch aperture and 26 inches focal length; 10-inch horizontal circle and 8-inch vertical circle, read to 10″ by two verniers to each circle.

„ 38. (12) 18-inch Borda repeating circle, by Troughton, $2\frac{1}{3}$-inch aperture and 24 inches focal length; the circles divided on silver, the horizontal circle being read by four verniers, and the vertical circle by three verniers, each to 10″.

„ 39. (13) 8-inch vertical repeating circle, with diagonal telescope, by Troughton and Simms; circle divided on silver, reading to 10″; a 5-inch circle at eye-end, reading to single minutes; horizontal circle 9 inches diameter in brass, reading to single minutes.

„ 40 (14) A set of surveying instruments, consisting of a 12-inch theodolite for horizontal angles only, reading to 10″; two sets of adjusting plates; tripod stand with enclosed telescope; heavy stand for theodolite; Y piece of level; two large and three small ground-glass bubbles divided; level collimator, object-glass $1\frac{6}{8}$-inch diameter and 16 inches focal length; micrometer eyepiece, comb, and wires; mercury bottle and trough.

„ 41. (15) Level collimator with object-glass $1\frac{7}{8}$-inch diameter and 16 inches focal length; stand, rider-level, and fittings.

„ 42. (16) 10-inch reflecting circle by Troughton, reading by three verniers to 20″; counterpoise stand; artificial horizon, with mercury; two tripod stands.

„ 43. (17) Hassler's reflecting circle, by Troughton, with counterpoise stand.

„ 44. (18) 6-inch reflecting and repeating circle, by Troughton and Simms, contained in three boxes, two of which form stands. Circle divided on silver, reading to single minutes; two inside arcs divided to single degrees, 150 degrees on each side; artificial horizon and mercury.

„ 45. (19) 5-inch reflecting and repeating circle, by Lenoir, of Paris.

„ 46. (20) Reflecting circle, by Jecker, of Paris, 11 inches in diameter, with one vernier reading to 15″.

„ 47. (21) Box sextant; reflecting plane and level.

„ 48. (22) Prismatic compass, by Troughton and Simms.

„ 49. (23) Mountain barometer.

„ 50. (24) Prismatic compass, by Thomas Jones, mounted with a cylindrical lens.

„ 51. (25) Ordinary $4\frac{1}{2}$-inch compass with needle.

No. 52. (26) Dipping needle, by Robinson.

 ,, 53. (27) Compass needle, mounted for variation.

 ,, 54. (28) Magnetic intensity needle, by Meyerstein, of Göttingen; a strongly fitted brass box with heavy magnet; filar suspension.

 ,, 55. (29) Box of magnetic apparatus.

 ,, 56. (30) Hassler's reflecting circle, by Troughton; a 10½-inch reflecting and repeating circle, with stand and counterpoise, divided on platinum with two movable and two fixed indices; four verniers reading to 10″.

 ,, 57. (31) Box sextant and glass plane artificial horizon, by Troughton and Simms.

 ,, 58. (32) Plane 2⅜-inch speculum, artificial horizon, and stand.

 ,, 59. (33) 2½-inch circular level horizon, by Dollond.

 ,, 60. (34) Artificial horizon, roof, and trough; the trough 8¼ by 4½ inches; tripod stand.

 ,, 61. (35) Set of drawing instruments, consisting of 6-inch circular protractor and common protractor, T-square; one beam compass.

 ,, 62. (36) A pantograph.

 ,, 63. (37) A noddy.

 ,, 64. (38) A small Galilean telescope with object-glass of rock crystal.

 ,, 65. (39) Five levels.

 ,, 66. (40) 18-inch celestial globe.

 ,, 67. (41) Varley stand for telescope.

 ,, 69. (43) Telescope, with object-glass of rock crystal.

 ,, 71. Portable altazimuth tripod.

 ,, 72. Four polarimeters.

 ,, 74. Registering spectroscope, with one large prism.

 ,, 76. Two five-prism direct-vision spectroscopes.

 ,, 78. 9¼-inch silvered-glass reflector and stand, by Browning.

 ,, 79. Spectroscope.

 ,, 80. A small box, containing three square-headed Nicol's prisms; two Babinet's compensators; two double-image prisms; three Savarts; one positive eyepiece, with Nicol's prism; one dark wedge.

 ,, 81. A back-staff, or Davis' quadrant.

 ,, 82. A nocturnal or star dial.

 ,, 83. An early non-achromatic telescope, of about 3 feet focal length, in oak tube, by Samuel Scatliffe, London.

 ,, 84. A Hollis observing chair.

 ,, 85. Double image micrometer, by Troughton and Simms.

 ,, 86. 4½-inch Gregorian reflecting telescope, by Short, with altazimuth stand and 6-inch altitude and azimuth circles and two eyepieces.

No. 87. 3¼-inch Gregorian reflecting telescope with wooden tripod stand.

„ 88. Pendulum with 5-foot brass suspension rod, working on knife edges, by Thomas Jones.

„ 89. A Rhabdological Abacus. A contrivance invented by Mr. H. Goodwyn, consisting of a box filled with compartments, in which are square rods covered with numbers, which can be arranged so as to facilitate the labour of multiplying high numbers.

„ 90. An Arabic celestial globe of bronze, 5¾ inches in diameter.

„ 91. Astronomical time watchcase, by Professor Chevallier.

„ 92. 2-foot protractor, with two movable arms, and vernier.

„ 93. Beam compass, in box.

„ 94. 2-foot navigation scale.

„ 95. Stand for testing measures of length.

„ 96. Artificial planet and star, for testing the measurement of a fixed distance at different position-angles.

„ 97. 12-cell Leclanché battery.

„ 98. 2 feet 6 inch navy telescope with object-glass 2½ inches, by Cooke, with portable wooden tripod stand.

„ 99. 12-inch transit instrument, by Fayrer & Son, with level and portable stand.

„ 100. 9-inch transit instrument, with level and iron stand.

„ 101. Small equatoreal sight instrument, by G. Adams, London.

„ 102. Sun-dial, by Troughton.

„ 103. Sun-dial, by Casella.

„ 104. Sun-dial.

„ 105. Box sextant, by Troughton and Simms.

„ 106. Prismatic compass, by Schmalcalder, London.

„ 107. Compass, by C. Earle, Melbourne.

„ 108. Prismatic compass, by Negretti and Zambra.

„ 109. Dipleidoscope, by E. Dent.

„ 110. Abney level, by Elliott.

„ 111. Pocket spectroscope, by Browning.

„ 112. Universal sun-dial.

„ 113. Double sextant, by Jones.

„ 114. Two models, illustrating the effects of circular motions.

„ 115. A cometarium.

„ 116. A pair of 18-inch globes.

„ 117 118 } Two old sun-dials.

No. 119. Specimens of diffraction gratings, by Prof. W. A.
Rogers.

„ 120. A 6-prism spectroscope, by Browning.

„ 121. Spitta's improved maximum and minimum thermometer.

„ 122. A 6-inch speculum, with flat; the speculum said to be by Sir W. Herschel, and re-figured by Sir J. Herschel.

„ 123. A 6-inch refracting telescope, by Grubb, with 3 eyepieces.

„ 124. Position micrometer, by Cooke.

„ 125. A 6-inch refracting telescope, by Simms, with eyepieces and solar diagonal.

„ 126. $3\frac{1}{2}$-in. portable refracting telescope, by Tulley, with tripod stand (bequeathed by the late Mr. W. H. Bartlett).

The following instruments are lent, during the pleasure of the Council, to the undermentioned persons :—

No. 4.   The *Beaufoy* transit instrument, to the Observatory, Kingston, Canada.

„ 5.   Herschel 7-foot reflector (two mirrors only), to Mr. A. A. Common.

„ 9.   7-foot Gregorian reflector (mirror only), to Mr. A. A. Common.

„ 10.   Variation transit, to Mr. Maxwell Hall.

„ 16.   The *Wollaston* telescope, to Mr. R. Inwards.

„ 22.   The *Matthew* equatoreal, to Mr. J. Brett.

„ 23.   The *Matthew* transit, to Captain W. Noble.

„ 27. (1) 30-in. transit and one stand, to Mr. C. Thwaites.

„ 28. (2) 6-inch theodolite and stand, to Mr. A. A. Common.

„ 29. (3) Equatoreal mounting, clock movement, and pillar, to Mr. W. Peck.

„   „   Wire micrometer (No. 1), to Mr. C. Thwaites.

„   „   Wire micrometer (No. 2), to Mr. Maxwell Hall.

„ 30. (4) $3\frac{1}{4}$-inch equatoreal and stand, to Mr. E. B. Powell.

„   „   „ Double image micrometer, to Mr. Maxwell Hall.

„ 34. (8) Transit instrument and stand, to Professor C. Pritchard.

„ 38. (12) 18-inch *Borda* repeating circle, to Mr. Maxwell Hall.

„ 39. (13) 8-inch repeating circle, to Mr. J. Norman Lockyer.

„ 42. (16) 10-inch reflecting circle and stand, to the Rev. H. P. Slade.

„   „   „ Artificial horizon, roof, and mercury bottle, to Mr. C. Thwaites.

„ 50. (24) Prismatic compass, to Mr. Maxwell Hall.

„ 52. (26) Dipping needle, to Mr. Maxwell Hall.

No. 54. (28) Magnetic intensity needle, to Mr. Maxwell Hall.
„ 69. (43) Telescope, with rock-crystal object-glass, to Dr. W. Huggins.
„ 78. 9¼-inch reflector and stand, to Mr. Maxwell Hall.
„ 79. Spectroscope, to Mr. Maxwell Hall.
„ 86. 4½-inch Gregorian reflector by Short (two mirrors only), to Mr. A. A. Common.
„ 122. 6-inch speculum and flat, to Mr. A. A. Common.
„ 123. 6-in. refractor by Grubb, to the Rev. A. Freeman.
„ 124. Position micrometer by Cooke, to Mr. J. E. Drower.
„ 126. 3½-inch portable refracting telescope by Tulley, to Dr. S. Johnson.

The Gold Medal.

No Gold Medal has been awarded by the Council this year.

OBITUARY.

The Council regret that they have to record the loss by death of the following Fellows and Associates during the past year:—

Fellows:—Major-General John Baillie.
Thomas Bauchope.
Warren De la Rue.
H. S. W. Evans.
Charles Hood.
R. S. Newall.
Rev. S. Parkinson.
Rev. S. J. Perry.
G. E. Ranken.
G. F. Riddiford.
G. W. Royston-Pigott.
James Smith.
C. J. Lambert (1888).
Associates:—Gaetano Cacciatore.
Lorenzo Respighi.
Wilhelm Tempel.

THOMAS BAUCHOPE was born at Brucefield, in Midlothian, in the year 1823, and succeeded his father as factor on several estates in Midlothian. In this position he earned for many years the confidence and the esteem of all with whom he had dealings. He combined with other professional duties those of a land surveyor; but the chief delight of his life was the science of astronomy, which he pursued with all the ardour of a devoted student.

For many years he made observations with a telescope he had mounted in his garden, and only a short time before his death he had ordered a much more powerful instrument, for which he had erected a new observatory. He contributed a series of popular articles on astronomy to a local newspaper. He was of a modest and retiring disposition, of a kindly heart, and gentle and unobtrusive in his manner. Nothing gave him greater pleasure than to find some working-man or young person exhibiting an interest in the science which brought such delight to himself.

Mr. Bauchope was elected a Fellow of this Society November 11, 1887.

WARREN DE LA RUE was born at Guernsey on January 18, 1815, and was the son of Mr. Thomas De la Rue, the founder of the eminent firm of manufacturing stationers in London. He was educated at the College Saint-Barbe in Paris, where he remained until he returned to London to enter his father's business.

But little, unfortunately, is known of the early career of one who in after life occupied so distinguished a position in the scientific world.

From an early age mechanics and machinery had a strong attraction for him, and possessing a shrewd inventive faculty, he devoted himself so successfully to technical work that he became a good engineer without having received any special training. His mechanical skill was evidently of a high order, and found its appreciation among those with whom he was associated, for at the early age of 23 he was entrusted with the erection of some large white lead works, the drawings for which he made entirely himself. Mr. De la Rue's ability and intelligence at this time are well displayed in the fact that his drawings were found to be so carefully prepared as to need no alteration, and the works were erected upon his designs with entire satisfaction.

Some year or two before this period he had begun to devote himself in his leisure to electrical researches, in which he afterwards attained so eminent a position. The first scientific paper he appears to have published was one dated September 15, 1836, when he was living in Bunhill Row, and which is printed in the *Philosophical Magazine* for December of that year, "On Voltaic Electricity, and on the Effects of a Battery charged with Sulphate of Copper." In this paper he gives an account of experiments made with a battery in which he used a saturated solution of sulphate of copper as the exciting agent. This principle had independently been employed by Daniel in his researches in voltaic electricity, but was relinquished by him as it failed to give a constant combination.

From this time until 1848 Mr. De la Rue appears to have devoted his scientific thoughts mainly to chemical and physical researches, for in this period we find papers by him "On the Agency of Caloric," "On the Structure of Electro-precipitated Metals," "On a Crystallised Alloy of Zinc, Iron, Lead and Copper," and "On Cochineal."

The earliest mention in the *Monthly Notices* of his attention being directed to astronomy appears in the number for December 1850, when a very beautiful drawing of *Saturn*, made by him with his 13-inch reflector, is announced to be exhibited the following month. This drawing fully confirmed Mr. Bond's discovery of the crape ring made on the 15th of the previous month. The same number of the *Monthly Notices* contains a brief note by Mr. De la Rue on his method of drawing double stars and nebulæ, which indicates that for some time previous to

this period he was in the habit of making observations of these objects with his large reflector.

This is the first reference to a telescope which afterwards became celebrated, and its history has, therefore, considerable interest. It was an equatorially mounted reflector of 13 inches aperture and 10 feet focal length, made in his own workshop, the optical portion being entirely his own handiwork.

From the following interesting reminiscence of him by Mr. James Nasmyth, we learn not only the origin of this historic telescope, but we ascertain also that Mr. De la Rue's thoughts were inclined to astronomy as early as the year 1840 :

" I well remember the visit I received from my dear friend Warren De la Rue in the year 1840. I was executing some work for him with respect to a new process which he had contrived for the production of white lead. I was then busy with the casting of my 13-inch speculum He watched my proceedings with earnest interest and most careful attention. He told me many years after that it was the sight of my special process of casting a sound speculum that in a manner caused him to turn his thoughts to practical astronomy, a subject in which he has exhibited such noble devotion as well as masterly skill. Soon after his visit I had the honour of casting for him a 13-inch speculum, which he afterwards ground and polished by a method of his own."

He was well acquainted with the labours of both Mr. Lassell and Mr. Nasmyth in the construction of telescopes, as is shown by the ready acknowledgment he made to the former " for his communication from time to time of his methods of manipulation," and to the latter " for many most valuable hints in polishing and grinding, more particularly for imparting to him a plan of producing a beautiful uniform surface to specula previous to the final pitch polishing." Indeed, it was Mr. Nasmyth who planted the germ that developed into the love for astronomy which characterised Mr. De la Rue throughout his life. The admission of this fact is contained in a letter to him from Cranford in 1864, in which he says, " No one has so great a claim on the fruit of my labours ; for you inoculated me with the love of star-gazing, and gave me invaluable aid and advice in figuring specula." This impulse wrought upon Mr. De la Rue's rare mechanical genius, so that he was able to effect improvements in the most approved methods of polishing the specula of reflecting telescopes, and perfecting the mechanical arrangements by which operations of such refined nicety are performed.

The mechanical means he adopted for figuring specula are fully described in his paper in the *Monthly Notices* for December 1852, upon which Sir John Herschel has thus commented : " Mr. De la Rue's machinery, though grounded on Mr. Lassell's rotatory principle, is by no means a servile imitation of Mr. Lassell, inasmuch as several distinct improvements have been introduced

tending to distribute the polishing action more equally over the whole surface of the metal.   One of these improvements consists in his interposition of a plate between the supporting plate and sliding plate of Mr. Lassell's traversing slide, which being made to revolve, causes the traversing movement of the speculum to take place, not across the same diameter of its area, but at every · stroke across a different diameter; and he also obviates the irregularity of the motion of Mr. Lassell's polisher on its centre, by governing that rotation by mechanism instead of leaving it to be determined by the excess of external over internal friction." . . . " Such is Mr. De la Rue's mechanism, which has afforded very admirable results in the production of specula of 13 inches in diameter and 10 feet focal length, the perfection of which is enhanced by his practice of bestowing the same care and precision on every step of the figuring of the speculum, from the grinding, the smoothing on a bed of hones, or rather a slab of slate cut into squares,* carefully brought to the same figure, and to the figuring of the polisher itself, which being thus previously rendered almost perfect, the speculum is saved the rough work of having to figure the polisher for itself on every occasion of repolishing."

It was the possession of this telescope of surpassing excellence, that subsequently enabled Mr. De la Rue to produce results in celestial photography and planetary delineation of such high and enduring value.

In 1851 and 1852 he demonstrated "his rare skill as a draughtsman as well as an observer" by the drawings of *Mars* and *Saturn* which he presented to this Society.   He continued such observations for some years until he had achieved those un-exampled representations of the planets, with which all are familiar, and which stand as models for imitation.

In 1851 Mr. De la Rue's attention was vividly attracted to a Daguerreotype of the Moon which was exhibited at the Great Exhibition of that year.   This had been taken by William Cranch Bond in the focus of the great 15-inch refractor of the Observatory of Harvard College.   Some Daguerreotypes of the Moon, taken by Messrs Whipple and Jones of Boston with the same instrument, were also exhibited at the meeting of this Society on May 9, 1851.

It was the sight of these very promising photographs which first gave the impulse to Mr. De la Rue's labours in this direction, and to the new field of research thus revealed, he at once devoted himself with an intelligent skill that soon made him the foremost pioneer of celestial photography in this country.

From the epoch of the first researches in photography by

* Mr. De la Rue's alteration of the plan adopted by Mr. Nasmyth consisted in substituting a slab of common slate for a grinder made up of squares of German blue stone (hone); the former having the advantage of always retaining its figure, which the hone-tool does not, when laid on one side for any length of time.

Daguerre in 1839 to the present day, the great progress of
photographic science is mainly due to the successive introduction
of two important methods—the first, the discovery in 1851 by
Mr. Scott Archer, Mr. Fry, and Dr. Diamond of the advantages
offered by collodion as the medium for the sensitive film, and
the second, the invention of the dry gelatine plate.   The
collodion process was brought into practical operation at a time
coincident with the exhibition in London of the Harvard pictures
of the Moon.   Mr. De la Rue was not slow to avail himself of a
method which offered such enormous advantages over that dis-
covered by Daguerre.

At the latter end of 1852 he made some successful positive
photographs of the Moon, employing the reflecting telescope
already referred to, which was then mounted in the garden of
his residence at Canonbury.   The necessary exposure was from
ten to thirty seconds, the images having a diameter of $1\frac{1}{10}$ inch.
The plan of operations may be best described in his own words.
" In taking these early photographs, I was assisted by my friend
Mr. Thornthwaite who was familiar with the employment of the
new medium (collodion).   At that period, I had not applied any
mechanical driving motion to the telescope, so that I was con-
strained to contrive some other means of following the Moon's
apparent motion; this was accomplished by hand; in the first
instance by keeping a lunar crater always on the wire of the
finder by means of the ordinary handgear of the telescope, but
afterwards by means of a sliding frame fixed in the eyepiece
holder, the motion of the slide being adjustable to suit the
apparent motion of our satellite; the pictorial image of the Moon
could be seen through the collodion film, and could be rendered
immovable in relation to the collodion plate, by causing one of
the craters to remain always in apparent contact with a broad
wire placed in the focus of a compound microscope, affixed at the
back of the little camera-box which held the plate."   Notwith-
standing the absence of any automatic driving motion, several good
positive pictures of the Moon were obtained, but the difficulties
encountered were so great that experiments were discontinued
until such time as clock motion could be applied to the instru-
ment.   This was not accomplished until the year 1857, when
Mr. De la Rue removed from Canonbury to Cranford in
Middlesex.   There he mounted the telescope with a remark-
ably good driving-clock, and resumed his experiments in celestial
photography.   At the November meeting of this Society in
that year he exhibited some beautiful photographs of the Moon
obtained under these new conditions.

In his first attempts, he obtained positive pictures, but in
1857, he made experiments with negative collodion plates, not
only because they admitted of more easy multiplication, but
mainly because the image was finer in grain.   Employing a
method suggested to him by Mr. Howlett, he was able to obtain
good negatives with an exposure of 10 seconds.

Mr. De la Rue's pictures of the Moon possessed great sharpness of definition and accuracy of detail, and admitted of considerable amplification—they would indeed bear examination under a magnifying power of 16. Until the appearance in 1865 of Mr. Rutherfurd's pictures of the Moon, the Cranford lunar photographs remained unequalled, to testify to the assiduity and skill he had displayed in overcoming all the difficulties attendant upon their production.

Mr. Wheatstone's ingenious invention of the stereoscope suggested to Mr. De la Rue the happy idea of combining, by means of that instrument, photographs of the Moon of the same phase, but differing only in libration. Upon these stereoscopic pictures Sir John Herschel has remarked : "Nothing can surpass the impression of real corporeal form thus conveyed by some of these pictures, as taken by Mr. De la Rue with his powerful reflector, the production of which (as a step in some sort taken by man outside of the planet he inhabits) is one of the most remarkable and unexpected triumphs of scientific art."

On comparing the photographs with the image of the Moon viewed in the telescope, Mr. De la Rue discovered two important features, which he announced to this Society in November 1857. He found that points on the lunar surface which have optically equal intensity of light, do not produce equally brilliant positive, and equally obscure negative impressions ; and he also observed that those portions of the lunar surface which are illuminated by a very oblique ray from the Sun, do not produce an equal effect on the sensitive plate, though they are equally bright to the eye.

At the meeting in the following month, he exhibited some photographs of great beauty of *Jupiter*, *Saturn*, and the double star *Castor*. On that occasion he read a noteworthy paper on the photographic determination of the relative light of the Moon and the planets *Jupiter* and *Saturn*—the important conclusions to which he came were that the actinic power of the Moon to *Jupiter* is about six to five or six to four ; and that the chemical rays of *Jupiter* are twelve times more energetic than those of *Saturn*.

Mr. De la Rue's connection with solar physics may be said to date from the early part of the year 1854. In April of that year Sir John Herschel suggested to the Kew Committee of the British Association that arrangements should be made for securing daily photographic representations of the Sun. He considered that a telescope with a 3-inch object-glass would be sufficiently powerful, and advised that the image should be formed not in the focus of the object-glass, but in that of a secondary magnifier. The object of this arrangement was to obtain a considerably magnified image of the Sun, and also to allow of a system of spider lines being photographed on the plate. On May 3 the Kew Committee requested Mr. De la Rue to ascertain the probable cost of such an apparatus. On the 29th of the following June the Council of the Royal Society, in

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consequence of an application made to them on the subject, decided to grant the necessary funds, and the instrument was forthwith constructed by the late Mr. Ross. It should be noted, however, that the cost of this photographic apparatus was eventually defrayed out of a fund placed at the disposal of the Council of the Royal Society by the late Mr. Oliveira.

The photoheliograph, which is an equatorially-mounted photographic telescope, was devised entirely by Mr. De la Rue. It had an object-glass of $3\frac{4}{10}$ inches aperture * and 50 inches focal length. It was not corrected for achromatism in the ordinary manner, but so as to produce a coincidence of the visual and photogenic foci. The secondary magnifier was of the Huyghenian form, with a system of fixed micrometer wires between the lenses.

The Kew solar photographic operations were inaugurated by Mr. De la Rue in March 1858, when the first pictures were obtained. The subsequent observations are too well known to need detailed description. The work was continued regularly for fourteen years—1858–1872—when it was discontinued at Kew, and the instrument transferred to Greenwich, where photoheliographic observations have since formed part of the routine work of the Royal Observatory. The results were communicated to the Royal Society in a series of important memoirs by Mr. De la Rue in conjunction with Professor Balfour Stewart and Mr. Loewy, entitled "Researches on Solar Physics." The credit of having successfully established a convenient system for the daily record by photography of the condition of the Sun's visible surface belongs undoubtedly to Mr. De la Rue.

At the meeting of the British Association at Aberdeen in 1859, Mr. De la Rue presented an exhaustive report "On the State of Celestial Photography in England" at that time. This paper forms a most complete and valuable monograph on the art, in which all instrumental, chemical and astronomical questions bearing on the subject are succinctly described and explained. Attention had been directed to celestial photography in this country for eight years, but though some other observers had occasionally made experiments, there had been no systematic pursuit of this branch of astronomy in England except by Mr. De la Rue in his own observatory, or under his immediate superintendence at Kew.

At this time Mr. De la Rue had decided to take the Kew photoheliograph out to Spain, to endeavour to photograph the red flames which might be seen during the total solar eclipse of July 18, 1860; but he had doubts whether the light

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* The aperture of the telescope was usually reduced to two inches, as early experiments led him to conclude that, for an image of the Sun of any given size, when once the aperture of the telescope which is sufficient to produce the picture with the necessary degree of rapidity has been ascertained, it is not beneficial to increase that aperture; that is to say, no more details are depicted, nor does the picture become sharper than when the smaller aperture is used.

of the prominences would be sufficiently intense to imprint themselves on the sensitive plate. He had formed the opinion that the light of the corona and red flames taken together was not greater than the light of the full Moon, and he found that with an exposure of three minutes, employing the full aperture of the photoheliograph, he could obtain only a very faint impression of the Moon. The well-known expedition to Spain, which he has described so fully and so graphically in the Bakerian Lecture for 1862, was therefore undertaken with considerable misgiving as to the results that might be secured. Those results are now matter of history. The two photographs, which were obtained during totality, each with an exposure of sixty seconds, when compared with the photographs taken by Padre Secchi at a position some 250 miles distant, removed all remaining doubts as to the real existence and solar character of the red flames, by exhibiting them on the plates gradually covered up on one side, and uncovered on the other side of the Sun, by the progress of the Moon. Mr. De la Rue's comparison of these photographs showed that the images of the prominences in both series accorded in their most minute details; and he establishes an important point in the following words : " The photographs must, from the difference of position of the two stations, have been made at an absolute interval of about seven minutes ; and this fact, while it strongly supports the conclusion that the protuberances belong to the Sun, at the same time shows that there is no change in their form during an interval much greater than the whole duration of an eclipse."

In the history of celestial photography in this country Mr. De la Rue stands pre-eminent. Perhaps no words could define his position with greater justice, than those made use of by the late Dr. Lee in presenting to him the Gold Medal of this Society : " Mr. De la Rue's claim to the special notice of astronomers, as a delineator of celestial objects through the medium of photography, does not rest on the absolute priority of his application of a well-known art in a new direction. It is rather based on the fact that, by methods and adaptations peculiarly his own, he has been the first to obtain automatic pictures of the Sun and Moon, sufficiently delicate in their detail to advance our knowledge regarding the physical characters of those bodies, and admitting of measurements astronomically precise." The tribute that was then paid to a mind so highly cultivated, whose energy had been directed for so many years to the attainment of scientific perfection, met with a wide sympathetic response.

In 1864 he was elected President of this Society ; and the period for which he held that position was marked by the delivery of two very able addresses : the first in presenting the Gold Medal, in 1865, to Professor G. P. Bond for his work on Donati's Comet ; and the second in 1866, when a like honour was awarded to Professor Adams for his contributions to the Lunar Theory.

In 1873 Mr. De la Rue terminated his observational labours in astronomy by offering to the University of Oxford his far-famed reflecting telescope and the greater part of the contents of his observatory, on the sole condition that they should be usefully employed. On November 27 of the same year Convocation accepted this generous gift, and authorised the expenditure of a sum of money for the erection of suitable buildings. His sympathy with practical astronomy was now transferred to Oxford, and henceforth it was a constant pleasure to him to assist and encourage the excellent work of the observatory that sheltered his old telescope.

In 1887 he took great interest in Admiral Mouchez's scheme for charting the heavens by means of photography, which was discussed at the International Congress, that assembled at Paris in April of that year; and on becoming acquainted with the results of the conference, he, in the most generous and liberal spirit, placed a considerable sum of money at the disposal of the Oxford University Observatory, to provide a suitable photographic telescope, so as to enable its distinguished director to take a full share in this important undertaking.

In 1873 Mr. De la Rue had removed from Cranford to London, and in the following year he fitted up a private physical laboratory near his house in Portland Place, where, employing a battery at first of 11,000, and finally of 15,000 chloride of silver cells, he, in conjunction with Dr. Hugo Müller, carried on an elaborate series of researches on the electrical discharge. The results were communicated to the Royal Society in a series of four Memoirs published in the *Philosophical Transactions*.

It remains but to mention that over a long period he pursued many important chemical researches which met the appreciation and recognition of the Chemical Society by his election to the president's chair for two periods, viz. from 1867 to 1869, and again from 1879 to 1880. We have already referred to some of his early papers. The nature of his chemical work appears to have been mainly technological, and the discoveries he made were, in one case at least, of considerable pecuniary value to him. At the Great Exhibition of 1851, Mr. De la Rue was a member of the jury, and reporter of Class XXIX. In this connection his attention was particularly attracted to the processes and manufacture of Price's Patent Candle Company, and the interest he took in the matter is shown by the Jury Report. He subsequently made some researches on "Rangoon Tar," published in the Proceedings of the Royal Society, which led him to patent a process to improve the special manufacture of Messrs. Price & Co., from whom, in consequence, he received a considerable sum of money. In his own business, his scientific knowledge enabled him to introduce a great number of improvements in processes and machinery which cannot be more particularly referred to here, but conspicuous among them may be mentioned the envelope-making

machine, which was one of the attractions of the Exhibition of 1851.

It is impossible in this brief notice to adequately record all the eminent services to science rendered by Mr. De la Rue. The various papers and memoirs that will be found in the Transactions of the Royal, the Royal Astronomical, the Chemical and other societies, testify to his genius and consummate skill in those branches of practical astronomy, solar physics, and technical chemistry with which he was peculiarly identified. But there is no record of what constitutes one important item in the sum of his usefulness; for it is only those who served and were associated with him on scientific committees, who can measure the wisdom and good sense of his counsel, his generous and disinterested devotion, and the charm and geniality of his manner.

He was always ready to assist important astronomical work with his purse and his influence. Many Fellows of the Society will remember the admirable *soirée* which, as President, he gave to the Society, at his own expense, at Willis's Rooms, on January 17, 1866. In 1876 he showed his opinion of the value of Mr. Gill's proposed expedition to Ascension by offering to contribute a large sum towards it, if the funds could not be obtained from other sources; and more recently at the meeting of the Council of this Society, when it was proposed to apply for a Government grant for some extensive lunar computations, Mr. De la Rue privately urged the writer of this notice not to delay putting the work in hand, as he would advance the money.

By these characteristics of a generous nature, as well as by his masterly power, he won for himself the respect, the honour, and the devotion of all who knew him, and made his name illustrious among men.

He had been in feeble health for some time, but after a short illness from an attack of pneumonia, he died on April 19, 1889 at the age of 74.

Mr. De la Rue was elected a Fellow of this Society on March 14, 1851. He was one of the honorary secretaries from 1855 to 1862. In 1862 he received the gold medal of the Society "for his astronomical researches, and especially for his application of photography." He was President from 1864 to 1866, and from that time till his death was nearly continuously a member of the Council. He was elected to the Royal Society in 1850. The list of honours he received is a long one. Oxford conferred upon him the degrees of M.A. and D.C.L. In 1864 he received a Royal Medal from the Royal Society "for his observations on the total eclipse of the Sun in 1860, and for his improvements in astronomical photography." He was for many years President of the London Institution, from which he retired in 1878, and became Secretary of the Royal Institution in succession to Mr. Spottiswoode, who was elected President of the Royal Society.

This post Mr. De la Rue resigned in 1882. In 1872 he was President of Section A of the British Association. He was one of the founders of the Royal Microscopical Society. He was a corresponding member of the French Académie des Sciences for the department of astronomy; also of the Imperial Academy of Sciences, St. Petersburg, the Philomathic Society of Paris, the Royal Society of Upsala, the Society of Agriculture and Commerce, Caen, the Society of Natural Science, Cherbourg, and the Berlin Chemical Society. Three foreign Orders had been conferred upon him—Commander of the Legion of Honour, Commander of the Order of St. Maurice and St. Lazare, and Knight of the Order of the Rose, Brazil. Mr. Warren De la Rue retired from the firm of Thomas De la Rue & Co. at the end of 1880.   E. B. K.

HARRY SAVILE WARD EVANS was born at Torquay on January 18, 1851. He was the younger posthumous son of William Bertram Evans, M.P. for Leominster, and Jane his wife, of Forde Abbey, Dorset, and Wimbledon Park House.

He was educated at Eton and Trinity College, Cambridge, where he graduated in the Moral Sciences Tripos in 1872. He was called to the Bar at the Inner Temple, but never practised. While at Trinity he was captain of the Cambridge University Volunteer Corps, and devoted great attention to rifle-shooting, and was for some years a member of the "English Eight" team at Wimbledon, and also of the British team when they competed in the United States against the Americans.

For the last seven or eight years he spent the greater portion of his time on a property he had acquired at Gulf Hammocks, Florida, U.S.A. He died in Paris, after a very few days' illness, on September 10, 1889.

He was elected a Fellow of this Society March 12, 1875.

CHARLES HOOD was born in 1805, and was the son of an iron-founder in Blackfriars. For many years after his father's death he and his brother carried on the business, from which he retired some time ago.

Mr. Hood attained considerable eminence in practical science. His researches into the chemistry of the combustion of coal gained for him the silver medal of the Society of Arts. He was consulted by the Government on the ventilation and warming of the new Law Courts, when, however, the work had proceeded too far to allow of his suggestions being adopted. His treatise on ventilation and warming by hot water is the standard work upon the subject. For this he was awarded the Telford Medal by the Society of Engineers. At the time of his death he was nearly, if not quite, the oldest Fellow of the Royal Society in date of election. He was one of the founders of the British Home for Incurables (chairman from 1861 to 1866), to which

he was a generous donor. He also took an active interest in the management of King's College and Westminster Hospitals.

He was elected a Fellow of this Society January 11, 1833.

ROBERT STIRLING NEWALL was born in Dundee on May 27, 1812. Though engaged in commercial business practically the whole of his life, his interests and talents were obviously of a kind that would have made him excel in purely scientific work, had the opportunity for the necessary early training and the external conditions presented themselves. He had a very keen power of observation, unusual patience and perseverance in research, a quiet persistence in following up a line which he knew to be correct in spite of prevalent opinion, and a great confidence in experimental methods. It was an opportunity for experimental work, afforded by Mr. Robert McCalmont, that induced him to give up work in Dundee, where his father's influence had gained him employment in a mercantile office. He came to London, and undertook for Mr. McCalmont experiments on the rapid generation of steam, and turned his mind to various other subjects of an experimental nature.

Always quick in devising mechanical arrangements, he readily seized upon a suggestion made by a friend who was studying mining in Saxony, and wrote that wire ropes of reasonable and efficient construction were greatly needed to take the place of the rough bundles of wire then used in the mining operations. Mr. Newall discovered the essential points in the construction of a good wire rope, and invented machinery to carry out the necessary operations.

In a short memoir in which the chief interest will be centred in astronomical subjects, the reference to Mr. Newall's interest in submarine telegraphy must be very brief, though he was occupied with the matter for at least fifteen years of a very active life. He received some of the first gutta-percha that reached this country; he suggested the wire-rope casing for the insulated telegraph lines; he constructed most of the first submarine cables, and personally took part in the laying of many of them.

In all the ordinary activity of his life between the years 1849 and 1865, when he was personally superintending the construction, testing, and laying of the cables, he still had time and inclination for numerous distinct pursuits, chief amongst them being astronomy. There exists a series of drawings of the sun, made by Mr. Newall and continued by him through the years 1848-1852. He was married on February 14, 1849, to the youngest daughter of the late Mr. Hugh Lee Pattinson, F.R.S. Doubtless it was in great part the intimate connection with Mr. Pattinson following his marriage that kept Mr. Newall's scientific interests alive in these busy years. Astronomy was one of the many subjects in which they found common ground and took practical interest. Mr. Pattinson had a 7¼-inch equatoreal by Cooke of York: this was a large glass in those days, when a 15-inch was the largest

refractor in existence. It was this telescope that Mr. Pattinson put at Professor Piazzi Smyth's disposal for his Teneriffe expedition.

The possibility of the construction and mounting of very large refractors was a subject of very frequent deliberation between Mr. Pattinson and Mr. Newall. It was only after Mr. Pattinson's death—he died in 1858—that unexpectedly the realisation of their dreams became possible. Mr. Newall saw in the Exhibition of 1862 the rough discs of crown and flint glass exhibited by Messrs. Chance, of Birmingham, and after the exhibition he acquired them, and they were transferred to the workshop of Messrs. T. Cooke & Sons, of York. The rough work of grinding and preliminary polishing had proceeded far enough to show the worth of the glass, and the agreement as to the finishing and mounting was completed in September 1863. The finished object-glasses were seen at the meeting of the British Association at Newcastle in 1865, but there were innumerable delays in the completion of the mounting, and it was not till July 1871 that Cooke could say the 25-inch equatoreal was finished. Mr. Newall designed and devised many of the arrangements himself, and helped, urged, and pressed Cooke to finish the work quickly; but when finally the telescope was completed, the plans originally made for its destination were no longer realisable. The telescope and observatory remained in the garden at Ferndene, where it had been set up in order that it might be completely put together before it was moved to a southern climate.

Of the success of at any rate one part of his experiment he was well aware from his own observations with the completed telescope. But had he been no observer himself, external testimony from the best sources would soon have convinced him.

The long delay in the completion of the instrument, which Cooke undertook in 1863 with the promise of finishing within twelve months, was a great disappointment and vexation to Mr. Newall; the more so as in those years of delay his business engagements became of a kind that would not permit him to leave England for any length of time. He scarcely needed the employment of an observer for several years to convince him that the climate of Gateshead was wholly unsuited, or rather impossible, for astronomical observations, and it was out of the question to move an incomplete instrument to a distant country, however favourable, even had his circumstances permitted. But he did not lose sight of his original purpose, and, doing all in his power to secure the completion of his first intentions, he made not one but several offers of his telescope in quarters where he expected the offer would be readily accepted. In 1875, when there was talk of the formation of a Physical Observatory, he had offered the loan of his telescope for application to the development of Physical Astronomy. The reading of *Six Months in Ascension* roused old longings in him again,

and one result following on it was the offer of the telescope and dome in 1879 for Mr. David Gill's use for seven years at the Cape of Good Hope. The circumstances which led to this offer being declined are already recorded in the *Monthly Notices.** In the last weeks of his life he returned again to his efforts to secure success for his experiment, and on March 2 of last year (1889) proposed to give his telescope to the University of Cambridge, with a view to its being devoted to the study of Stellar Physics.

Mr. Newall was active in local matters, being Mayor of Gateshead in 1867 and again in 1868, an alderman of the borough, and Justice of the Peace. In 1876 he became a representative of the borough on the River Tyne Commission. He became a Fellow of the Royal Society in 1875, a member of the Institute of Mechanical Engineers in 1879, and in 1887 he received the honorary degree of D.C.L. at Durham University. He died in the 77th year of his age, on April 21, 1889.

He was elected a Fellow of this Society May 13, 1864.

STEPHEN PARKINSON was born at Keighley, in the West Riding of Yorkshire, in the year 1823. He received his early education privately, and was subsequently elected to a sizarship at St. John's College, Cambridge, which in due course was changed for a foundation scholarship, as it was evident that he was a student of unusual diligence and ability. In the Mathematical Tripos of 1845 Mr. Parkinson came out as Senior Wrangler, and when it is remembered that the second place was filled by Sir William Thomson, it is plain that his work must have been of more than ordinary excellence. In the competition for the Smith's Prizes, Sir William Thomson asserted his unusual gifts, but Mr. Parkinson easily distanced all others for the second prize.

After this achievement Mr. Parkinson was elected to a fellowship of his college, and settled down to private teaching. He eventually succeeded the Rev. J. B. Mayor as tutor, and to this post, with a lectureship attached, he devoted himself for twenty years. Ordained at Ely upon his fellowship, Mr. Parkinson proceeded B.D. in 1855, and D.D. in 1868. The *Cambridge Review* states that, "As a lecturer he was distinguished by unusual lucidity of exposition, and he published an *Elementary Treatise on Mechanics*, and a *Treatise on Optics*, which had wide vogue among students. As a tutor Dr. Parkinson is remembered by his pupils for his excellent business qualities, especially his care not to spare any trouble in giving explanations by assuming that his pupils already were perfectly acquainted with the matter in hand; but still more for his frankness and kindness of heart." Among his college pupils were four senior wranglers, Moulton, Pendlebury, Ward, and MacAlister.

* Vol. xl. p. 236.

Dr. Parkinson for a short time acted as President of his college. He examined for the Mathematical Tripos in 1849 and 1852, and was on the Council of the Senate more than once. He was a Fellow of the Royal Society, and was elected a Fellow of this Society March 11, 1853.

STEPHEN JOSEPH PERRY was born in London on August 26, 1833, and was the son of Mr. Stephen Perry, a member of a well-known firm in Red Lion Square. He received his early education at Gifford Hall School, and then went to France to study at the college at Douay, where he was so successful in his mathematical work as to carry off the first prize. From Douay he proceeded to the English College at Rome for theological training, as he was destined for the priesthood, and in 1853 he entered the Society of Jesus.

It was in 1856 that Father Perry first came to Stonyhurst to go through the usual course of mental philosophy and physical science. His special aptitude for mathematics was soon perceived, and in the same year he was appointed to assist the Rev. A. Weld, who was then Director of the Observatory.

In 1858, on matriculating at the London University, he went up for mathematical honours, taking the sixth place. After this he was sent to London for a year to study under Professor De Morgan, and then for another year to Paris, where he attended the mathematical lectures of Liouville, Delaunay, Serrat, Cauchy, and Bertrand.

In the autumn of 1860 he returned to Stonyhurst, being appointed Professor of Mathematics and Director of the Observatory, as successor to Father Weld, who had held that position for many years. In the autumn of 1863 he left to complete his theological course at St. Beuno's College, in North Wales, where he was ordained priest in 1866 ; and when all his studies were completed he came back finally to Stonyhurst in 1868 to resume charge of the observatory, which he continued to direct until the day of his death.

The first important scientific work Father Perry undertook, was in the autumn of 1868, when he spent the vacation in making a magnetic survey of the west of France, in which he was assisted by the Rev. W. Sidgreaves, S.J. The instruments employed were those in constant use for the monthly observations of the magnetic elements at Stonyhurst. Complete sets of observations of dip, declination, and horizontal force were taken at fifteen different stations, and the elements reduced to January 1, 1869, the secular variations being obtained by comparison with Lamont's observations made ten years previously.

In the following year this survey was continued and extended to the eastern part of France, the months of August and September being devoted to it. Complete sets of observations were made at twenty-one stations, and the elements reduced to the same epoch. In both series two sets of observations were made

at Paris.   Thus the magnetic elements of thirty-five different stations, well distributed over France, were determined by the same observers with the same instruments.

Father Perry's attention had been directed to the unsatisfactory character of the magnetic elements in Belgium, and he considered that a new series of determinations was rendered necessary in consequence of previous observers having chosen very few stations in that country, and especially as the curvature of the isodynamics and isoclinals in Lamont's maps indicated some very considerable disturbing cause.   In 1871, therefore, he, assisted by Mr. W. Carlisle, undertook a new magnetic survey, when complete sets of observations were made at twenty different stations.

The result was to indicate that the coal measures, which stretch completely across the south-eastern portion of the country, exercise a strong disturbing influence, so much so as to completely mask the normal direction of the lines.

The results of these magnetic surveys were all published in the *Philosophical Transactions.*

In 1870 Father Perry was chosen as chief of the expedition to Cadiz to observe the total eclipse of the Sun, the results of which he communicated in a paper published in the *Monthly Notices.*

In 1872 he commenced regular observations of the phenomena of *Jupiter's* satellites, employing the 8-inch Troughton and Simms Equatoreal.   These have been continued to the present date, and, with the exception of the period 1875–1877, when there existed unavoidable hindrances to the prosecution of the observations, they form a fairly connected series, which have been published in the *Monthly Notices.*

In 1874 Father Perry was appointed to the command of the important expedition to Kerguelen Island to observe the transit of *Venus.*   It is unnecessary to refer particularly to the observations made on that occasion, which have all been published in the official account, and fully discussed in the *Monthly Notices.* But he has recounted his experiences of the whole expedition in some graphic and delightful "Notes of a Voyage to Kerguelen Island to Observe the Transit of *Venus,* December 8, 1874," published in the *Month and Catholic Review* in 1876.

He, with the Rev. W. Sidgreaves, his companion in the French magnetic work, left England in the latter part of June 1874 and arrived at the Cape of Good Hope July 20, where all the members of the party were assembled.   Various accidents and hindrances occurred which prevented the expedition leaving Cape Town till September 18.   The voyage to Kerguelen, or Desolation Island, in H.M.S. "Volage" was an eventful one from the heavy weather and exceedingly rough sea that were experienced.   Father Perry was throughout life a martyr to seasickness, which never left him so long as he was on board ship, but his narrative contains no word of his own sufferings in a

voyage which must have been full of pain and discomfort, and, indeed, not without peril.

Few persons have probably realised what was involved by going to this island to observe the planet *Venus* pass across the Sun's disc. The desolate situation, almost 3,000 miles away from any habitable spot; the dreary aspect of an island of rock and lake and bog, without man, or beast, or tree to break the monotony of its loneliness; and, most of all, the fearful approach through mist and storm, with waves the greatest in the world, and winds blowing a gale for five days out of every seven : and yet it was this cheerless island that Father Perry and his companions inhabited from October 8 to the 26th of the following February, with weather in which, he says, they were never free from the danger of a heavy fall of snow, even at midsummer, and with a wind which seldom failed to blow fully half a gale in the course of forty-eight hours. On the eventful December 8 the sky was very hazy and Father Perry's observations of the ingress of *Venus* were in consequence very imperfect; but as egress approached the Sun cleared a little, without, however, being brilliant, and he was able to secure both contacts. His work, however, was not over. Sir George Airy had pointed out to him, as he did to the meeting of this Society in November 1874, the necessity for an absolute determination of longitude at Kerguelen. This meant one hundred double observations of lunar altitude, or azimuth, and thirty transits of the Moon over the meridian. When we learn from Father Perry's "Notes" that up to December 8 only five transits and a proportionate number of azimuths had been secured, we may well admire the enthusiasm and the high sense of duty that impelled him and his party to settle down for a further twelve weeks' work in this inhospitable clime; that being the utmost time it was calculated to be prudent to stay, on account of the stock of provisions; and even that accompanied with the prospect of a home journey of many thousand miles upon half rations. As he modestly puts it, "We must not deny that there was a little grumbling, but the work was done, and, we hope, thoroughly." On the homeward voyage a cyclone, which flooded everywhere, with wind blowing a hurricane and the ship rolling at times more than 45°, was one of the most perilous trials he experienced.

But these discomforts and hardships seem only to have inspirited Father Perry to devote himself in the future to like expeditions, for in 1882 he again took charge of an expedition to the south-west coast of Madagascar to observe the transit of *Venus*. On this occasion he was accompanied by Father Sidgreaves, who had been his companion at Kerguelen, and by Mr. Carlisle, an assistant at the Stonyhurst Observatory. The party left England on August 29 and arrived at Madagascar October 22 in H.M.S. "Fawn." The insecurity on the main island made Father Perry select the small island of Nos Vey for his observing station. Nos Vey is a heap of sand, three-quarters of

a mile in length by one-quarter in breadth, surrounded by a coral reef, and inhabited by French and English traders, with about sixty native families from the mainland. On the south point of this sandbank he erected his instruments. On the day of the transit, notwithstanding a high wind and showers of fine sand, which fell over the instruments, satisfactory observations of internal contact at ingress were secured by all the observers. The particulars of these observations have been published in Mr. Stone's official report.

In 1886 Father Perry went out to the West Indies with the British expedition to observe the total solar eclipse of August 29 in that year. His station was at Hermitage, on the island of Carriacou. For the observation of this eclipse he took out the 5½-inch equatoreal by Alvan Clarke, which had formerly belonged to the Rev. T. W. Webb. He devoted himself to spectroscopic observations, the report of which has been published in the *Philosophical Transactions.*

In 1887 he was nominated by the Council as a representative of this Society, to observe the solar eclipse of August 19. For this purpose he accepted the hospitable invitation of Professor Bredichin, and proceeded to the town of Pogost, on the Volga, but on account of the bad weather he was unable to secure any important observations.

Soon after his return from Kerguelen in 1875 Father Perry had turned his attention to solar physics, and had inaugurated a series of solar drawings and measurements of the chromosphere, in which he was materially assisted by the special aptitude for drawing such objects displayed by one of his assistants, Mr. McKeon. This work has been continued uninterruptedly since 1879, and includes a careful drawing of the solar surface on every available occasion (made by projecting the image on a screen), and also a complete measure of the Sun's chromosphere, to which, in 1882, a spectroscopic examination of Sun-spots was added. Many of the results have been published in the *Monthly Notices,* in astronomical journals, and in the published annual volumes of the Stonyhurst meteorological and magnetical observations.

In an interesting paper contributed to vol. xlix. of the *Memoirs* of this Society, Father Perry has discussed the correctness that can be attained by solar drawings, from an examination of Greenwich photographs and Stonyhurst drawings made on the same days. In this paper he calls attention to the curious fact that whereas the mean daily spot area in the photographs is in excess of that in the drawings, the reverse is the case with the faculæ, which in the drawings are largely in excess. An account of the Stonyhurst solar work formed the subject of Father Perry's lecture to the Royal Institution last May.

Up to the time of his leaving England on his last fatal expedition, it was his full intention, at the earliest possible time, to prepare a work embodying a complete discussion of the results derivable from the solar and magnetic observations he had

carried out at Stonyhurst. This work had been planned out with the object of throwing light upon theories of Sun-spot formation, and on solar physics generally, and also to find, if possible, a clue to the nature of the connection between Sun-spots and terrestrial magnetism. Before leaving Stonyhurst last November he instructed his assistant to prepare the materials and be ready when he came back to commence a systematic study of the life history of each group of spots recorded in the Stonyhurst drawings, and also to investigate all the spots for each year studied collectively on a chart. This work was intended to be exhaustive of the material he had accumulated, which he considered might be sufficient to throw important light on the subject of the proper motions in spots, on the connection between spots and faculæ, the recurrence of spots in the same heliocentric position, and many other questions of solar physics. The remarkable observations of veiled spots which Father Perry brought before the Society in January 1888 indicate that the method of projection adopted is capable of furnishing results of considerable interest and value. It is a serious loss to astronomy that his untimely end has prevented so hopeful an investigation from being conducted under the auspices of the author and originator of the work.

In the early part of 1889 the Council invited Father Perry to take charge of the Royal Astronomical Society's expedition to French Guiana to observe the total solar eclipse of December 21–22, 1889. He at once, with the enthusiasm that was characteristic of his nature, accepted the confidence that was placed in him, and from that time till he left England in November spared no effort in his preparations to fulfil his mission in the most satisfactory manner to astronomy and to the Society.

The programme of the operations for observing the eclipse has already been published in the present volume, and we need not here make further reference to it; but the story of his last fatal expedition is too romantic not to be recorded in some detail.

Father Perry, accompanied by Mr. Rooney, one of his colleagues at Stonyhurst, left Southampton on November 14, in the Royal Mail s.s. "Tagus," and arrived at Barbados on November 26. On December 2 he left Barbados in H.M.S. "Comus," Captain Atkinson, and arrived at the Isles du Salut, near Cayenne, on December 7, anchoring at "Royal Island." During the voyage the weather was very rough, and he suffered severely from sea-sickness. Notwithstanding the resulting prostration, he insisted upon landing the evening of his arrival, in order to examine the site for the observatory, and to introduce himself to the French authorities, from whom he received the greatest courtesy and assistance.

He took up his quarters at the military hospital, where two very good rooms were placed at his disposal by the Commandant. It was soon discovered that the sanitary arrangements of the

whole island were very bad, and, notwithstanding the urgent and repeated request of Captain Atkinson that he would sleep each night on board the "Comus," he insisted upon passing the night at his quarters. Had he acceded to that request, it is probable his life would have been spared; but his fear of giving trouble to others, his high sense of duty, and his conscientious desire to accomplish his work in the most successful manner, were with him paramount considerations over any personal discomfort or danger. On December 20 it was discovered that he was in seriously bad health; indeed, his companions considered him in feeble health all the time he was on the island. At last this forced itself upon him so much that he acknowledged to Captain Atkinson that he felt himself to be unfit for the work.

The rain, which had set in on the 18th, caused the weather to be very unhealthy. A large number of convicts on the island were ill with dysentery, and deaths were occurring at the rate of four or five a day. On the 20th he complained of being very ill, but the night clearing up after the heavy rain, he rashly determined to remain at the observatory all night to secure some trial photographs. He worked on till 3 A.M., and when his men retired on board the "Comus," he merely lay down in a hammock in the tent, so as to be ready to take the position of the Sun at rising just before 6. Doubtless the fatal chill was here received, for the same night, December 21, he was very ill with cramp and diarrhœa; so ill, indeed, that it was feared he could take no part in the observation of the eclipse; but the enthusiasm and self-denying spirit that had carried him through so many previous difficulties, were not yet to be quelled by bodily ailment, and on the morning of the eclipse he managed, with the assistance of a seaman, to walk the rough and difficult half-mile from his quarters to the observatory, and declined to allow himself to be carried on a stretcher. He at once took his place at Mr. Common's large photographic instrument, and conducted the whole proceedings.

Up till about twenty-five minutes before totality a heavy black cloud had completely obscured the Sun, but this cleared off at the critical moment, and allowed him to make, in the most satisfactory manner, all the observations which he had travelled so far to accomplish. The success of the observations seemed to give him new life; he was alert and self-possessed, and was really much better. He stated that he had never conducted so successful an observation of the Sun's eclipse before. He then asked Captain Atkinson to call for three cheers for the successful observation: "I cannot cheer," he said, but he waved his helmet. After uttering these words, which convey so much that is touching and pathetic, the effort of strength he had called up to nerve him to the fulfilment of his mission was soon dissipated, and he rapidly became dangerously ill. Of the last moments of his life there is little to tell. On the afternoon of the eclipse he was taken on board the "Comus," and put to bed

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in the captain's cabin, suffering from the most virulent form of
dysentery. On the 26th he was better, and the "Comus" at
once proceeded with all despatch for Demerara, but on that
night gangrene of the lower bowel showed itself, and Father
Perry died at 4.20 P.M. on the 27th. When told he was dying,
he calmly sent for Mr. Rooney, and gave him full directions
about everything connected with the eclipse, told him where his
notes were, and left nothing undone. He was enthusiastic to the
last, and in his wanderings just before death he rehearsed the
operations which took place at the observation station during
the eclipse. His body was landed at Demerara on December 28,
where it was at once interred in the old Catholic cemetery.

Thus died Father Perry, through a devotion to duty which
will always ennoble his name, and rank him in the long list of
those who have made allegiance to the call of duty their supreme
guide : "Not only religion and war, but even astronomy has its
heroes."

At their meeting on January 10, 1890, the Council of this
Society recorded in their minutes the following resolution,
which was passed unanimously : "The Council, having heard
with the deepest regret of the death of the Rev. S. J. Perry
while on the Society's expedition to observe the total eclipse at
the Salut Isles, desire to put on record their sense of the great
loss which astronomy has suffered by the death of so enthusiastic
and capable an observer, and to offer to his relations and to
his colleagues at Stonyhurst the expression of their sincere
sympathy and condolence on this sad event."

As a professor, Father Perry's chief characteristics were the
extreme care he took in the preparation of his lectures, and the
earnestness he threw into his work. What he undertook, that
he did as thoroughly as lay in his power, whether it were astro-
nomical observations, or teaching mathematics, or playing games
with the boys at Stonyhurst. In this respect his characteristic
was concentrativeness, coupled with a charming, simple earnest-
ness that captivated respect and esteem. Loyalty to science
and to his college were part of his nature, and a word at the
expense of either roused him at once. As a public lecturer
on astronomical subjects he was very effective and popular.
He delivered lectures at the Royal Institution, in many places
in the north of England, and on one occasion, in 1887, he lectured
in French at Brussels. His last lecture was to the crew on board
the "Comus," and his last sermons were preached in French
on December 8 and 15 to the convicts at the Salut Isles. Thus
his life passed simply and laboriously, without pretence or
affectation, and, great as was his devotion to science, his desire
was still greater to do his duty in the state of life he had chosen,
in whatever direction that duty might be appointed for him.

Father Perry was elected a Fellow of the Royal Society in
1874, and was made a member of its Council last November.
In 1886 he received the honorary degree of D.Sc. from the

Royal University of Ireland. He was a member of the Royal Meteorological, the Physical, and the Liverpool Astronomical Societies, of which last he was President. He was also a member of the Accademia dei Nuovi Lincei, of the Société Scientifique de Bruxelles, and of the Société Géographique d'Anvers. For several years he served on the Solar Physics Committee and on the British Association Committee for comparing and reducing magnetic observations.

He was elected a Fellow of this Society April 9, 1869, and served on the Council for several years, and in December last he was proposed by the Council as one of the Vice-Presidents for the ensuing year.   E. B. K.

GEORGE ELLIOT RANKEN was born in the year 1828, and was educated at Eton and Oxford. His career at Eton was brilliant and exceptionally successful, and at the age of eighteen he entered University College, Oxford, on the foundation, having won the scholarship the previous year. His tutor at Oxford was the late Dean Stanley, who often prophesied great things of his future. Soon after taking his degree he became a student at the Inner Temple, and then entered the War Office as private secretary to Sir Edward Lugard. On resigning this position Mr. Ranken settled in Rome, where for some years he was attached to the Papal Court, having been appointed a Privy Chamberlain by Pope Pius IX. In the year 1871 he returned to England and became editor of the *Tablet*, a position which he held until about five years ago, when ill-health compelled him to resign it.

In the year 1859 Mr. Ranken married Georgina Elizabeth, daughter of the Rev. H. W. Buckley, Rector of Hartshorne, Derbyshire, by whom he leaves two children, a son and a daughter.

Mr. Ranken was a man of more than ordinary accomplishment. His early training and the reading of his lifetime had left him with a memory singularly well stored, and with the more important results of an habitual retentiveness. His love for literature was liberal and most intelligent, and he fed it on the works of many languages, his linguistic talent being remarkable. To his familiarity with the modern literature of Europe he added a ripe and an accurate scholarship, which made his opinion upon any question connected with the classics specially valuable. In the problems of astronomy he found a resource and a pleasure which even his failing health never seemed to impair. But it was only those who knew Mr. Ranken well—perhaps only those who lived in habitual and professional intercourse with him—who ever fully realised how gifted he was and in how many ways.

He was elected a Fellow of this Society January 13, 1882.

GEORGE FRANCIS RIDDIFORD, who died at Barnwood Lodge, near Gloucester, on December 6, 1889, was born at Gloucester in

1841, and subsequently articled to Messrs. Wilton, solicitors, of that place. When admitted, he was received into the firm as a partner, and ultimately became its sole representative. He had a very extensive practice of the highest class, and he held many valuable public appointments, being Registrar of the County Court; County Treasurer; Clerk of Indictments; and Clerk to the Income Tax Commissioners, as well as of many public companies. In all these capacities he brought to bear a very sound judgment, a wide knowledge, and unswerving integrity. He devoted considerable attention to scientific pursuits, and possessed large scientific knowledge, especially upon the subject of astronomy, the study of which occupied much of his leisure time. He built an observatory in his grounds, and fitted it with a 12-inch reflecting telescope by Browning, a transit instrument, sidereal clock, and other requisites.

It is interesting to know that his observatory and all its contents, together with a full set of spectroscopic apparatus, have been presented by his widow to the Gloucester School of Science, in which he took a keen interest, and where it is hoped that they will serve to promote the study of astronomy.

He was elected a Fellow of this Society January 11, 1878.

GEORGE WEST ROYSTON-PIGOTT was the youngest son of the Rev. Solomon Pigott, for many years Rector of Dunstable. He entered the University of Cambridge in 1838 and graduated as twenty-second Wrangler in 1841, his mathematical tutor being the Rev. W. R. Griffin, and soon after taking his degree he was elected to a Fellowship at Peterhouse. He continued in residence at Cambridge for several years longer, pursuing the study of medicine, and took the degree of M.D. there in 1851. Dr. Royston-Pigott attained distinguished success as a physician during his subsequent residence at Harrogate, but after some years he retired from the active duties of his profession. Meanwhile he never relaxed the favourite studies which led him into the domains of astronomy and the world of marvels revealed by the microscope. He was a mechanician of the first order, and many details of his costly and beautiful instruments were wrought by his own hands or carried out under his direction.

Finding himself at one time baffled by the imperfections of even the best microscopic objectives, he set himself to investigate the causes of the residuary aberration and to devise means for correcting it. Here his knowledge of mathematical optics told. By means of corrections of his own devising, applied to the highest powers of the instrument, he succeeded in resolving objects of hitherto invincible difficulty, and pointing out to other observers most interesting lines of work. It was in recognition of his eminent service to science in this respect that he was, in 1873, elected Fellow of the Royal Society. Shortly after this a Fellowship in the Royal College of Physicians was offered to him, which, however, having then retired from medical practice,

he thought it right to decline. The record of Dr. Royston-Pigott's work is not contained in any great production, but lies scattered in numerous papers published in the Transactions of the Royal and other societies, and a record more abiding and more useful perhaps remains in improvements in various scientific instruments and more refined methods of research suggested by him. His ideas and discoveries were freely made public from time to time for the benefit of all who might find them useful.

He died at his residence at Eastbourne, September 14, 1889.

He was elected a Fellow of this Society, February 12, 1869.

GAETANO CACCIATORE was born at Palermo on March 17, 1814. He was the son of Catarina Emanuela Martina and Nicolo Cacciatore, the distinguished Director of the Palermo Observatory and the successor of the illustrious Piazzi.

Gaetano Cacciatore received his education at the Istituto Nautico and the University of Palermo, where he pursued his mathematical studies until the year 1834. In the following year he was placed under the guidance of his father as Second Assistant at the Observatory of Palermo, and in 1839 he succeeded to the position of First Assistant. On the death of his father in 1841 he undertook provisionally the direction of the Observatory, which position he held until the year 1843, when he was appointed Professor of Astronomy at the University of Palermo and Director of the Observatory.

In 1842 he commenced the publication of the *Annuario* of the Palermo Observatory, which contained astronomical ephemerides, meteorological observations, &c.

In 1848 he took an active part in the Sicilian revolt, and became a Deputy to the Sicilian Parliament, where he assisted in decreeing the downfall of the Bourbons. On the restoration of the reigning family, in 1849, Cacciatore refused to retract his action, and consequently he was banished from Palermo, and the Chair of Astronomy became vacant.

Cacciatore, being thus deprived of his observatory and astronomical work, took up the profession of engineer to the sulphur mines of Grotta Calda, for which he was much indebted to the generosity of the Prince of Sant Elia.

On the liberation of Sicily by Garibaldi in 1860, he was recalled to his former position at the Observatory and to the Professorship of Astronomy at the University.

Notwithstanding the long absence of ten years from his observatory and astronomical pursuits, his enthusiasm for his favourite science led him to devise means to raise the Palermo Observatory to a higher and more important position.

In 1863 he mounted under a large dome the fine equatorial refractor by Merz, of 9·8 inches aperture and $14\frac{1}{2}$ feet focal length. In the same year he began the publication of the *Bullettino Meteorologico* of the Palermo Observatory, which up to 1872 contained astronomical notes and memoirs; after that time

this was discontinued, and the astronomical researches of the
Observatory appeared in the *Memorie della Società degli Spettro-
scopisti*, then published by M. Tacchini at Palermo.

In 1879 Cacciatore obtained from the Government a more
complete reorganisation of the Observatory into the three sections
of Astrophysics, Meridian Astronomy, and Meteorology; each
section having a staff of two assistants and a servant.

In 1880 he founded the Meteorological Observatory, which
was established in an excellent position in the district of Valverde,
about 1½ kilometre west of the Observatory, and supplied with
the necessary instruments.

In 1882 he undertook another series of publications—viz.,
the *Publicazioni* of the Palermo Observatory, which contains the
more important researches of the three sections referred to above.
He published three volumes and began the fourth, which his
death unfortunately prevented his completing. This has since
been published by Signor Ricco, the present Provisional Director
of the Observatory.

Professor Cacciatore was vice-president of the Italian com-
mission for the observation of the solar eclipse of 1870, and was
instrumental in organising the observing stations and publishing
the results in a volume which appeared in 1872 under the title
Eclisse Totale di Sole del 1870. He was President of the Faculty
of Mathematical, Physical, and Natural Sciences for nine years,
and for many years he was Director of the Engineering School at
Palermo. He also held an important position in the municipality
and the province of Palermo. Among other distinctions, Professor
Cacciatore was a Commander of the Order of the Crown of Italy
and an officer of the Order of St. Maurice. He was a member
of the Italian Spectroscopic Society and of the Royal Academy
of Palermo.

He died on June 16, 1889, to the great regret of his
colleagues and friends, who loved him much for his rare good-
ness of heart and his exquisite courtesy of manner.

He was elected a Foreign Associate of this Society December
13, 1844.

LORENZO RESPIGHI was born at Cortemaggiore, Piacenza, on
October 7, 1824, and was the son of Luigi Respighi and
Giuseppina Rossetti. He studied at Parma and at the Univer-
sity of Bologna, where, in 1847, he took his degree in philosophy
and mathematics. In 1849 he was appointed Professor of
Mechanics and Hydraulics at the University of Bologna. Two
years afterwards he became Professor of Astronomy, and in
1855 was appointed Director of the Observatory at Bologna.

Most of Professor Respighi's voluminous scientific work is
published in the transactions of the Istituto di Bologna, the
Accademia dei Nuovi Lincei, and the Accademia dei Lincei.
His earliest publications were mainly meteorological.

In 1862 and 1863 he discovered three comets, the observa-

tions of which were published in 1865, in which year he was appointed Professor of Astronomy at Rome and Director of the Observatory of Campidoglio.

Among the astronomers who have devoted themselves to the spectroscopic study of the solar prominences, Professor Respighi stands in the foremost rank. In 1869 he commenced the series of observations which has made his name celebrated in this branch of research. Pursuing his observations with extraordinary assiduity, he in less than three years sketched and mapped more than 8,000 prominences. He systematically and assiduously continued these researches for more than fifteen years, and he thus accumulated a mass of observations which are of high importance to the advancement of our knowledge of solar physics. His results are contained in some nine or ten papers published in the transactions of the academies mentioned above.

From 1874 to 1882 he made a very extensive series of observations of the Sun's diameter, and published two papers on the alleged variation in that diameter.

To meridian astronomy Professor Respighi has contributed three catalogues of the mean declinations of stars of the first to the sixth magnitudes, made with the Ertel Meridian Circle which was given to the observatory by Pope Pius IX. The first, in 1877, is a catalogue for the epoch 1875·0 of 285 stars within the parallels $+20°$ and $+64°$. The second, published in 1880, supersedes the first, and contains 1463 stars within the same parallels and for the same epoch. This paper contains an exhaustive determination of the latitude of the observatory and a comparison of the catalogue with Auwers' Fundamental and the Greenwich Nine-year Catalogues. The result is to show that Respighi's declinations are of a high value. In 1884 he published his third catalogue of mean declinations, for the epoch 1880·0, of 1004 stars comprised within the parallels $+0°$ to $+20°$ and $+64°$ to the pole.

Numerous other contributions to astronomy by Professor Respighi are to be found in the publications of several of the Italian academies which we cannot more particularly refer to here.

He died at Rome on December 10 of the past year. He was elected a Foreign Associate of this Society November 8, 1872.

ERNST WILHELM LEBERECHT TEMPEL was born on December 4, 1821, at Nieder-Kunersdorf, near Löbau, in the kingdom of Saxony. His parents were people in poor circumstances, and so he received but a scanty education, which in after years he lost no opportunity of improving. When about twenty years of age he went to Copenhagen, where he worked for about three years as a lithographer, and where his lively manners and his taste for music and art acquired for him many friends, some of whom he never lost sight of. After leaving Copenhagen he went for some time to Christiania, and his roving spirit then brought him to

Italy, where he settled at Venice and exercised his art for
many years. Having become interested in astronomy he pur-
chased a 4-inch refractor by Steinheil, with which he began
exploring the heavens. It was a great encouragement to him to
persevere in this occupation (for which he had obtained leave
to use the balcony of a Venetian palace), that on April 2, 1859,
he succeeded in discovering a comet (1859 I), and thenceforth
he remained an enthusiastic observer until his last illness. He
was the first to notice (on October 19, 1859) the now well-
known nebula around *Merope* in the Pleiades, the announcement
of which, though confirmed by various observers with small
instruments, was received with much hesitation, as the object
was less readily seen with a larger aperture and higher power.

In March 1860 Tempel went to Marseilles, where he obtained
employment at the Observatory, which was then under the direc-
tion of Valz. He picked up his second comet (1860 IV.) in
October 1860, and also turned his attention to the minor planets,
of which he in the years 1861 to 1868 discovered five. He
remained attached to the Observatory till towards the end of
1861, when he settled in the Rue Pythagore, Marseilles, and
resumed his work as a lithographer. But Tempel continued to
show himself an indefatigable observer, and as he had only
his 4-inch refractor he was naturally induced to remain faithful
to the field of work in which he had first been successful—that of
comet-seeking. Among the eight comets which he found while
at Marseilles,* the first one of 1866 attracted great attention from
its connection with the November meteors, while the second one
of 1867 was found to belong to the interesting class of periodic
comets of short period. It was observed again in 1873 and
1879, but in 1885 was too distant and too faint to be seen.
Comet 1869 III., which was also discovered by Tempel, was in
1880 found to be periodic; it is known as Tempel's third periodic
comet, and passed the perihelion in May 1886, when it was too
unfavourably situated to be observed.

In January 1871 Tempel was as a German expelled from
France by the Provisional Government. He went to Milan,
where Professor Schiaparelli was glad to accept his services as
an assistant at the Brera Observatory. There he continued
observing comets, and discovered three new ones,† among which
his second periodic comet (1873 II.) is remarkable as having
a very short period—only a little over five years. It was ob-
served again in 1878, but was unfavourably placed with regard
to the earth both in 1883 and 1889. Tempel's observations made
at Milan, chiefly of comets, were published in the Milan ephe-
meris for 1872 and in No. 5 of the *Pubblicazioni* of the Brera
Observatory ; in the latter there is a fine lithographed plate of
the Pleiades with the *Merope* nebula, which he later improved

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* 1860 IV., 1863 IV., 1864 II., 1866 I., 1867 II., 1869 II., 1869 III.,
1870 I.

† 1871 II., 1871 IV., 1873 II.

by the addition of many minute stars, after which he repub-
lished it in the *Monthly Notices*, vol. xl.

Towards the end of 1874 Tempel left Milan to accept the
post of Assistant in charge of the Arcetri Observatory, which
is connected with the *Reale Istituto di studi superiori* of
Florence. Having now for the first time the use of larger
instruments, he thenceforth devoted himself to observations of a
more systematic character, and discovered only one more comet,
1877 V. In all he had been the first discoverer of thirteen comets
(counting 1870 I., which was detected both by him and by Win-
necke within a few minutes), while he found four which had been
detected somewhat earlier by other observers, * and one cometary
object (December 29, 1871) which could not be found again.

The Observatory at Arcetri had been erected in the years
1869–1872 from the designs of Donati, but when this energetic
astronomer died in September, 1873, the buildings, though exter-
nally finished, were not complete, and the mounting of the
largest instrument—a refractor by Amici, of 11 inches aperture—
was far from finished, so that there was neither clockwork nor
graduations on the circles. The building seems also to have
been badly constructed, as the walls of the meridian-room had to be
strengthened in 1875 to prevent them from giving way. Nobody
appears to have taken the slightest interest in the observatory
after Donati's death, and for fourteen years Tempel had to
struggle on, subsisting on a scanty salary, and endeavouring to
do good work with a half-finished instrument. The years which
Tempel had spent in comet-seeking had caused him to take a
great interest in nebulæ, and, notwithstanding all the obstacles
with which he had to contend at Arcetri, he resolved to apply
himself to observations of these objects. He had at his disposal
two instruments with object-glasses by Amici, both of which
were optically suitable for observing nebulæ. One was a refrac-
tor of 9·4 inches aperture and 10½ feet focal length, roughly
mounted on a portable stand, but it does not appear to have
been much used, as a slight wind was sufficient to set it in
motion on the sloping terrace, which was the only place where
it could be used. The other refractor has 11 inches aperture
and 17½ feet focal length, and is equatorially mounted under the
central dome; but mounting and dome have been so badly
designed that objects in altitudes less than 20° cannot be ob-
served. Undaunted by these difficulties, Tempel collected a
considerable number of observations of nebulæ. Many of his
results have appeared in a series of notes in the *Astronomische
Nachrichten* (vols. 90–113), from which it may be seen that
a great number of objects not observed elsewhere since Sir
W. Herschel's time have been examined and their places cor-
rected, and many new nebulæ found and micrometrically ob-
served. But, above all, Tempel devoted his attention to the

* These are: 1862 II., 1863 III., 1867 I., and 1874 II.

making of accurate drawings of the more interesting nebulæ, a
pursuit for which his artistic skill and experience made him
particularly fitted; while he had also the advantage of a very
pure sky and an instrument of sufficient aperture and excellent
defining power. A photographic reproduction of a drawing of
the nebula of *Orion* will be found in a short memoir on nebulæ
printed in 1885 in the *Abhandlungen der K. Böhmischen Gesell-
schaft der Wissenschaften* (reviewed in the *Vierteljahrsschrift*,
vol. xxii.).* A list of the drawings made at Arcetri was given in
the same memoir, comprising 186 nebulæ, or groups of nebulæ.
It would appear that steps were taken some years ago to have
these drawings published, as Tempel in 1886 sent the writer
of these lines a lithographed plate, which he described as a
failure, adding: "It belongs to my Roman work on nebulæ
(22 plates), which unfortunately will probably never be pub-
lished, as we hitherto have not found an artist capable of
copying my nebulæ." It is very much to be hoped that this
work may be published, together with Tempel's numerous notes
and measures (with an annular micrometer) of neighbouring
stars and companion nebulæ. In the beginning of 1887, when
he found himself unable to observe, Tempel began to arrange
and put in order his scattered notes and sketches, many of which
had as yet only been jotted down on various maps, and intended
to enter them all in a copy of Herschel's *General Catalogue*, in-
terleaved with two white leaves between each two pages, but we
are not aware whether he succeeded in completing this task.
We trust, however, that his Italian *confrères* will not allow his
work to be buried in oblivion, but that they will interest them-
selves in having it published in the same systematic and com-
plete manner in which the observations of Dembowski were
given to the world some years ago.

Tempel's mind, which always had been somewhat inclined
to melancholy, had in Italy found peace by embracing the
Roman Catholic faith. About the end of 1886 he was attacked
by a liver complaint, and some months later by partial paralysis.
He lingered till March 16, 1889, when death relieved him from
his sufferings. His mind remained clear to the last. He was
buried near the tomb of Donati, his predecessor in charge of the
Arcetri Observatory.

In addition to various prizes from the Vienna Academy for
his discoveries of comets, Tempel, in 1879, received the prize
which every six years is awarded by the Accademia dei Lincei for
some astronomical work. He was elected a Foreign Associate of
this Society June 10, 1881.   J. L. E. D.

* A drawing of the *Orion* nebula in 1861, drawn and lithographed by
Tempel, appeared in the *Ast. Nach.*, vol. 58.

PROCEEDINGS OF OBSERVATORIES.

The following Reports of the proceedings of Observatories during the past year have been received from the Directors of the several Observatories, who are alone responsible for the same.

Royal Observatory, Greenwich.

The Ten Year Catalogue of 4059 stars, epoch 1880, has been passed for press, and one or two copies were received before the end of the year. The large amount of work which has been done in reducing the observations to a uniform system, and in examining discordances, has been already referred to in previous Reports. It is to be further remarked that the number of stars is about double that of previous catalogues, as the following figures will show :

				No. of Stars.
Twelve	year	Catalogue	1840	2156
Six	,,	,,	1850	1576
First Seven	,,	,,	1860	2022
Second Seven	,,	,,	1864	2760
Nine	,,	,,	1872	2263
Ten	,,	,,	1880	4059

The reobservation of Groombridge's stars, commenced in 1887, has been steadily proceeded with, though occasionally retarded by special demands, such as the observation of comparison stars used by Dr. Gill and others at the oppositions of *Victoria* and *Sappho*. The number of close circumpolars regularly observed has also been increased by the addition of 10 stars, frequently used in longitude operations. The total number of transits observed in 1889 was 5343, and of zenith distances 5142 ; the total number of stars observed being 1650. Of these, 244 observations were made of 41 stars for *Victoria*, and 151 of 42 stars for *Sappho*; the planets themselves being observed on the meridian 15 and 9 times respectively. Meridian observations of Sun, Moon, and planets have been regularly continued as before.

The mean error in R.A. of Hansen's Lunar Tables, with Newcomb's corrections, as deduced from 92 observations with the

transit circle in 1889, is $+0^s\cdot010$, which is of the same sign as all the other mean annual values since the introduction of these corrections in 1882, but smaller than any previous value. The series from 1883 is $+^s\cdot032$, $+^s\cdot021$, $+^s\cdot028$, $+^s\cdot029$, $+^s\cdot065$, $+^s\cdot079$, and $+^s\cdot010$.

From January 1, 1889, circumpolar stars have been observed by the galvanic method, using the R.A. micrometer to bisect the star at a moment recorded with the other hand on the chronograph. Observations of the same transit by both methods made in the later months of 1889 show that no sensible systematic change in right ascension has been thereby introduced.

The results for level and azimuth error in 1889 show that the cleaning and adjustment of the Y's in January 1888 have not interrupted the gradual settling down of the instrument, which causes a tendency to a negative level error and a positive azimuth. The range of level in 1888 was $+7''\cdot0$ to $-2''\cdot0$; in 1889, $+5''\cdot7$ to $-3''\cdot6$. The range of azimuth in 1888 was $-8''\cdot2$ to $+3''\cdot3$; in 1889, $-6''\cdot6$ to $+6''\cdot0$.

On September 26 an amalgamated copper bottom was fitted to the mercury trough used in reflexion observations, which have been thereby rendered much more satisfactory. Tremors are not nearly so noticeable, and quicky subside. From comparison of observations before and after the change, it appears that the mean difference between two bisections of the same star at the same reflexion observation has been reduced from $0''\cdot80$ to $0''\cdot56$.

Observations of the horizontal flexure of the transit circle on January 3, April 18, May 14, 1889, and January 14, January 15, 1890, gave results $+0''\cdot08$, $+0''\cdot52$, $+0''\cdot26$, $+0''\cdot05$, and $+0''\cdot28$. No correction for flexure has been applied since April 1879, this correction being virtually included in the $R-D$ correction which for 1888 was $+0''\cdot75$ sin Z.D. The apparent correction to the nadir observation deduced from reflexion observations of stars in 1889 is $+0''\cdot072$. For the year 1888 this quantity was $-0''\cdot118$. No correction for this discordance has been applied.

Observations on the distribution of temperature in the transit circle room, by means of four thermometers suspended at different points, were continued throughout 1889. One of these thermometers (I) is close to the instrument; the others, N, S, and M, are at the north and south corners and in the middle, respectively, of the top horizontal shutter opening in the roof. An exterior thermometer (E) is just outside the north wall of the transit circle room, and another (F) is in the front court at a distance from the building. Simultaneous readings of these six thermometers were made on 350 occasions during evening observations in the years 1888 and 1889, the exterior temperature ranging from 27° to 67°. Care was taken in each case that all the observing shutters had previously been open for at least half an hour, and generally some hours, to ensure free circulation.

The results show that at the freezing-point for F the excess of readings of E, S, N, M, and I are respectively $0°\cdot3$, $1°\cdot0$, $1°\cdot4$, $2°\cdot0$, and $3°\cdot8$; and that for every $10°$ rise of temperature in F these differences decrease with some regularity by about $0°\cdot30$, $0°\cdot33$, $0°\cdot39$, $0°\cdot43$, $0°\cdot66$ respectively. A careful determination was made of the index errors, and the above quantities are corrected for index error; but in order to eliminate any residual index error from the difference of N and S, which is important as showing an unsymmetrical distribution of temperature, these thermometers have now been interchanged, and the observations will be continued in 1890.

Observations of the Moon have been made with the altazimuth as before in the first and last quarters. The long-focus lens for viewing a church spire distant 355 yards as a fiducial mark was mounted in February, and this mark has been regularly observed throughout the year; and also, when weather permitted, another mark distant 2200 yards from the instrument.

Comet *e*, 1888 (Barnard), was observed on one night; Comet *f*, 1888 (Barnard), on two nights; Comet *e*, 1889 (Davidson), on four nights, and Comet *d*, 1889 (Brooks), on one night, with one or other of the equatoreals. On the occasion of the close conjunction of *Mars* and *Saturn* on September 19, nineteen differential transits and N.P.D.'s of the planets were observed with the S.E. equatoreal, the results of which have been communicated to the Society.

Four disappearances and one reappearance of stars occulted by the Moon have been observed, and ten phenomena of *Jupiter's* satellites. Circumstances were not favourable for such observations in 1889. The occultation of *Jupiter* and his satellites by the Moon on August 7 was observed by five observers.

On May 15, 1889, two trial photographic objectives were received from Sir H. Grubb; one of 6 inches intended as a pilot for the 13-inch object-glasses to be used in charting the heavens; and one of 4 inches as a pilot for the 28-inch refractor which is being constructed for this observatory. Ten photographs were taken with the first lens, and the information thus obtained guided Sir H. Grubb in the construction of the 13-inch objectives. Some photographs taken at Dublin with one of these objectives were received in November, and micrometric measurements of stars on them to a distance of $80'$ from the centre were found satisfactory. Photographs taken more recently at Dublin with two other object-glasses made by Sir H. Grubb give equally satisfactory images up to a distance of $80'$ or $90'$ from the centre. Eighteen photographs were taken with the 4-inch pilot lens, to test the practicability of Sir G. Stokes' principle of reversing the crown lens to correct the spherical aberration introduced by the separation of the lenses, in order to convert a visual telescope into a photographic one. The most suitable distance of separation was determined experimentally, and satisfactory results were obtained, the images being very sharp.

On December 9 and following days the Astronomer Royal paid a visit to Sir H. Grubb's works in Dublin, and inspected the instruments in process of construction for Greenwich and the Cape.

In the spectroscopic department the observation of the displacement of lines in stellar spectra for the determination of their motion in the line of sight has been continued during the past year, and 429 measurements have been made of the displacement of the F line in the spectra of 50 stars, and 18 measures of the *b* lines in the spectra of 8 stars, besides 72 measures of lines in the spectra of Sun, Moon, or planets, as a check on the adjustment of the instrument and on the general accuracy of the work. The spectra of Comets Davidson and Brooks (July 6), and of χ *Cygni, R Andromedæ,* and *Uranus* were each examined upon one night.

With the photoheliograph, photographs of the Sun have been taken on 190 days, and 410 selected for preservation, including 14 photographs, with a double image of the Sun, taken to determine the position of the wires with reference to a declination circle. The additional photographs received from India and Mauritius leave only six days in the year ending December 4, 1889, on which no photograph is as yet available for measurement.

The photographs for 1889 showed a continued falling off in the spotted area of the Sun, until June 16, when a period of greater activity commenced, which lasted until the beginning of October. This period was also marked by the appearance of several small spots in unusually high latitudes, both circumstances suggesting that the solar minimum was definitely past. The last three months of the year, however, have shown an almost entire absence of considerable spots.

One hundred and eighty-five photographs, taken at Harvard College, Cambridge, U.S., between the dates September 1, 1875, and November 29, 1876, have been received from the Solar Physics Committee. Of these, 95 have been found to fill up gaps in the Greenwich series, and so many of them as show spots or faculæ have been measured and reduced.

In 1885 a comparison was made between the areas of umbræ, whole spots, and faculæ, as measured upon 4-inch photographs by the two observers of each of twelve pairs of observers, in order to ascertain if there were any evidence of systematic personality in the estimation of areas. During the past year a similar investigation has been carried out for the twenty pairs of observers engaged in the measurement of 8-inch photographs. Both for the 4-inch and the 8-inch pictures the corrections to be applied to the measured areas on account of personality have generally been smaller than the probable error of the mean of two measures, and in the case of whole spots they are quite insignificant The details of these comparisons for 8-inch photographs, together with the determination of the probable error in the measurement

of the 4-inch photographs, will appear in the Introduction to the volume for 1888, the corresponding investigations, viz. the determination of the probable error of the measurements of 8-inch photographs, and of the effect of personality in the measurement of areas on 4-inch photographs, having been given in the Introduction to the Greenwich Observations for 1885.

During June and July the three pendulums which were used in the Indian Survey, and which had recently been swung at Kew, were set up in the Record Room under General Walker's supervision, and observations were made to determine their vibration periods at Greenwich.

These pendulum swings divide into two sets: in the first, the pressure of air in the cylinder in which the pendulum was suspended was reduced to 2 inches; in the second, to 27 inches. At the lower pressure the duration of each swing was 12 hours approximately, at the higher pressure 6 hours. About 8 swings were made with each pendulum in each set, the position of the pendulum being reversed during each set, so that each face of the pendulum-bob was towards the observer during half the swings.

The observations were reduced so as to exhibit the number of vibrations, in a mean solar day, of each pendulum swinging in a vacuum through an infinitely small arc, and at a temperature of 62° Fahr., a correction being afterwards applied to reduce to sea-level. The results as compared with those obtained at Kew are as follows :—

Number of Vibrations in Mean Solar day.

Pendulum.	At Greenwich.	At Kew.
4	86165·54	86166·50
6	86065·70	86066·61
11	86117·04	86117·03

Observations were made in June and July for determining the longitude Dunkerque-Greenwich by Commandant Defforges and Mr. Turner. The English reductions are complete to the first approximation, but the French have been somewhat delayed by the influenza epidemic. This longitude will serve as a check on the longitude Paris-Greenwich by completing a triangle with Dunkerque.

The reductions for the longitude Paris-Greenwich, for which numerous observations were made in 1888, have been seriously delayed by a curious discrepancy between the results obtained by English and French instruments, which has hitherto baffled all attempts at elucidation. It is hoped that the independent determination through Dunkerque may throw light on the matter.

In accordance with a request of the French Service Géographique observations were also made in July for simultaneously determining the difference of latitudes of Paris and

Greenwich by the method of the French Survey. The latitude deduced for Greenwich with the assumed places of the stars observed agrees with the adopted latitude within 0″·15, a quantity less than the probable error.

The comparison between Hansen's and Burckhardt's Tables of the Moon for the years 1847–1861, recently conducted under the auspices of the Royal Astronomical Society, rendered possible the comparison of the Greenwich lunar observations for those years with Hansen's Tables. This latter comparison has now been made under the supervision of the Astronomer Royal, and the results are being printed in the *Monthly Notices* of the Royal Astronomical Society.

During the summer Lieutenants Field and Cust, of the Royal Navy, made a number of observations at this observatory, to determine the relative advantages of the portable transit and of the sextant for nautical surveying.

The electrical connections and underground wires of the observatory, up to the points where they are connected with clocks or instruments, have been placed under the superintendence of the Post Office; and thus time, which was hitherto necessarily devoted to business in connection therewith, has been reclaimed for scientific work.

A clock with heavy pendulum has been rated for several months at the request of the constructor, Mr. R. Inwards.

It may be mentioned that the Astronomer Royal visited Pulkowa on the occasion of the Jubilee celebration (August 19, 1889), and attended the meeting of the Permanent Committee of the Astrophotographic Conference in September.

The volume of Greenwich Observations for 1887, including the Ten Year Catalogue and two other appendices, was passed for press in December, and is now being distributed. The volume for 1888 is well advanced.

The magnetical and meteorological observations have been carried on without any particular change. By means of two additional stoves placed in the magnet basement, in the beginning of the year 1889, it is practicable to regulate its temperature so that the variation between summer and winter is reduced to very small limits, being now, excepting in the extremes of winter cold or of summer heat, not more than 1° or 2°. The diurnal variation of temperature has always been small, so that the temperature correction (annual as well as diurnal) required for the horizontal and vertical force magnets is now very small.

It has been the custom since the year 1882 to give in the annual volume copies of the photographic magnetic curves for days of unusual magnetic motion, as such publication appeared to afford a valuable means for the directors of other observatories to make comparison with their results. A similar system has since been commenced at the Parc St. Maur Observatory in Paris. But as the days selected at the two observatories in different years were not quite the same, it has now been arranged,

in concert with M. Mascart, that the observatories shall act together in this matter, and the list of days for 1889 has already been selected and agreed upon. If other magnetic observatories would in future years join with Greenwich and Paris in concerted action for the publication of the magnetic curves on selected days, much would be done to facilitate the investigation of the phenomena of terrestrial magnetism.

At the end of the Introduction to the last published volume, that for 1887, there will be found accounts of experiments made on days of extreme heat bearing on the question of the effect of radiation from the ground and surrounding objects on thermometers ; a question interesting to astronomers as well as to meteorologists, as affecting the determination of astronomical refraction. There is (1) a table of readings of thermometers on the open stand, with the circular protecting radiation board alternately removed and attached ; (2) a table of readings of thermometers in a Stevenson Screen, with the door of the screen alternately open and shut ; and (3) a table of readings of the new thermograph, with certain protecting radiation boards alternately removed and attached. There is, further, an interesting comparison of results obtained by the old and new thermographs, as well as a comparison of the records, during one year, of the old Campbell form of sunshine instrument and the new Campbell-Stokes form.

The Thomson Electrometer, for indication of atmospheric electricity, which had been for some months out of use, was finally readjusted by Mr. White, of Glasgow, and again brought into use in October 1889.

The reduction of the twenty years' photographic records, published in 1878, dealt with the barometer records from 1854 to 1873, and the thermometer records from 1849 to 1868.   Since 1877 corresponding results have appeared in the annual volumes.   An appendix to the 1887 volume contains the reduction of the barometer photographs from 1874 to 1876, and of the thermometer photographs from 1869 to 1876, completing the reduction of the photographic records of the barometer and dry-bulb and wet-bulb thermometers since their commencement respectively in 1854 and 1849.

Royal Observatory, Edinburgh.

During the year 1889, the routine work of reducing the observations of the 55 stations of the Scottish Meteorological Society, as well as the daily meteorological readings and weekly record of the rock thermometers, have been continued as heretofore, under the care of Mr. T. Heath. The same remark applies to the time service by time-ball, time-gun, and electrically controlled clocks. Time signals have also been regularly transmitted to Dundee.

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In the course of the year the arrangements for building the new Observatory have slowly progressed. In the spring a committee for the consideration of a site and plans was nominated by H.M. Secretary for Scotland, consisting of Lord Crawford, Professor Tait, Lord McLaren, the late Mr. J. Reid, and Professor Copeland. The committee met on June 17, when Mr. W. W. Robertson, H.M. Surveyor for Scotland, attended by request. On this day a site was eventually selected in Blackford Hill Park, almost exactly two minutes of arc south of the present Observatory. The park being the property of the City of Edinburgh, application was made to the Edinburgh Town Council, who with the greatest liberality unanimously resolved to transfer to the Crown a suitable area of the park, on the sole condition that it was to be used only for the purposes of a National Observatory.

As the site is within 500 yards of the Suburban Railway, it became necessary to test it for stability. This was accordingly done with a 4-inch transit instrument brought from Dun Echt, between September 26 and October 24, the result being that the porphyrite rock of which the hill consists does not transmit any perceptible vibration from the railway, even when the heaviest trains are passing. This important point being decided, the transfer deeds and general plans of the Observatory and dwelling houses were directed to be proceeded with. Building operations will be commenced in the summer.

The instrument used for testing the site remains in position : by using it in the prime vertical Dr. L. Becker found the approximate latitude to be $55° 55' 57''·3$. At present a *Cassiopeiæ* passes the zenith between the two observatories, but, owing to its large precession in declination, it will not long offer the same facilities that Hooke's chosen star, γ *Draconis*, has so long afforded at London and Greenwich.

Professor Copeland took up his residence at Edinburgh on April 11, but Dr. Becker was able to remain at Dun Echt Observatory until September 25, which thus for a short time became a field station of the Edinburgh Royal Observatory. The interesting nature of the work thus rendered possible will be seen from the following summary. In the earlier months of 1889 Dr. Becker continued the observations of nebulæ, mentioned in former reports, with the transit circle. During 14 nights 114 places of nebulæ were secured. Unfortunately, the weather was very unfavourable at the time when the hours of R.A. 10^h to 14^h, so rich in nebulæ, were accessible. The spectroscopic observations of the low Sun on the Barmekin Hill were resumed in May. The brighter part of the spectrum from $\lambda = 602$ to 486 having been finished in the two previous years the survey could now only be extended on the clearest days. However, from May 8 to September 9, 2,610 measures of lines in the red end of the spectrum were made during fifteen settings and six risings of the Sun. The skies

were by no means so favourable for this class of observation as in the other two years, the horizon having been much obscured by haze in the month of June and by clouds in July. The whole of these observations will be ready for publication in a few weeks. Dr. Becker also made a careful study of 17 *Cygni* and β *Lyræ* with the smaller Grubb spectroscope attached to the 15-inch equatoreal. On eleven nights in June and July 457 measures of 70 bright lines in the spectrum of 17 *Cygni* were compared with the spectra of sodium, lithium and magnesium. Twenty-eight lines in the spectra of lead and zinc served as standards for the bright lines of β *Lyræ*, of which no less than 237 were laid down by 560 observations. D_3 is not amongst them. These measures have been reduced by the aid of a table computed by Ketteler's formula of dispersion. On October 28, the F line was seen exceedingly bright in R *Andromedæ* and in R *Cygni*, together with many other bright lines of less intensity. A prominent group of these lines occurs in the light of both stars near $\lambda = 517$, and there is a very bright one at 494·6. Bright lines were also suspected in several other stellar spectra, but the necessity of concentrating all work at Edinburgh put a stop to the investigations before decisive results could be obtained. Examined on twelve nights from August 18 to September 20 with a Fraunhofer-Secchi prism on the 6-inch Simms equatoreal, γ *Cassiopeiæ* showed C extremely bright, while the other hydrogen lines were seen with difficulty.

A place of comet Barnard 1888 *f* was obtained with the 15-inch equatoreal on January 26, and one of Davidson's comet on August 15. The latter observation was used in computing the orbit published in Dun Echt Circular No. 176. During the year twelve circulars were distributed. They deal almost altogether with comets. A concluding circular, No. 179, was published January 29, 1890. A second series has been commenced at Edinburgh, of which three were issued before the close of the year.

The printing of the text of the library catalogue is now finished.

In his spare time Dr. L. Becker has computed the definitive orbit of comet 1867 I, for which he has observed all the comparison stars at Dun Echt. The period comes out as 40 ± 4 years. By altering the period it becomes evident that it must lie between 30^y and 50^y, and most probably within the narrower limits of 35 and 45 years.

Since the beginning of the winter session Professor Copeland has lectured on Spherical and Practical Astronomy in the University of Edinburgh.

Royal Observatory, Cape of Good Hope.

Observations with the transit circle have been continued regularly throughout the year. The chief objects of observation have been the Sun, *Mercury* and *Venus*, stars in the list of the Cape ten year catalogue for 1890, comet comparison stars, stars occulted by the Moon, stars employed in the latitude determinations of the geodetic survey of South Africa, and stars employed in zones for determining the scale value of the heliometer. In addition the minor planets *Victoria* and *Sappho* and the selected comparison stars were observed during the period June 2 to November 22.

The work accomplished with the transit circle in 1889 has been as follows:—

Number of determinations of collimation . . . 53

,,　　　　,,　　level . . . . • 332

,,　　　　,,　　nadir . . • . 330

,,　　　　,,　　flexure . • . • 53

,,　　　　,,　　meridian mark . . . 74

Number of complete observations of the Sun (both limbs in both elements) 98

Number of complete observations of *Mercury* . . 49

,,　　　,,　　　,,　　*Venus* . . . 74

,,　　　,,　　　,,　　*Victoria* . . 49

,,　　　,,　　　,,　　*Sappho* . . . 28

	Direct.	Reflex.
Transits	4284	68
Observations of N.P.D. . . .	3604	68

Of the 42 *Victoria* comparison stars 564 meridian observations were obtained, and of the 38 *Sappho* comparison stars 465 observations.

From the want of an available assistant (no computer being available for any kind of observing), it was necessary to discontinue the use of the great theodolite during the year.

With the zenith telescope 863 pairs of stars have been observed by Talcott's (Horrebow's) method, partly in connection with Kapteyn's method of latitude determination, partly for control on the law of flexure of the transit circle, and for the connection of the northern and southern systems of declination.

The following occultations of stars by the Moon have been observed:—

Disappearances at the dark limb 18

Reappearances at the dark limb 8

Davidson's Comet was observed on eight nights; the results have been communicated to the *Astronomische Nachrichten.*

The heliometer has been kept in constant use during the year. The series of observations for stellar parallax, mentioned in last report, has been nearly completed. The minor planets *Victoria* and *Sappho* have been observed in conjunction with the observatories of Yale, Leipzig, Göttingen, and Bamberg, according to a carefully prepared programme. A heliometric triangulation of the comparison stars, necessary for the satisfactory reduction of the *Iris* observations, has been completed. The work of triangulating the comparison stars observed with *Victoria* has been begun. The solar eclipse of June 27 was observed with the heliometer, in response to a request from Professor Simon Newcomb, under very unfavourable circumstances of definition; but, as 144 pointings each of position angle and distance of the cusps were obtained, the result should be an accurate one. A preliminary discussion shows that the corrections to the *Nautical Almanac* place of the Moon, referred to the Sun, are very small.

In order to determine whether the radius of the slides is identical with the focal length of the heliometer-object-glass (in other words, to ascertain whether in converting observed distances into arc it is necessary to introduce a term depending on the square of the distance), two zones (distortion zones) were selected, each consisting of four stars, arranged nearly on a great circle, the distance of the extreme stars of each zone being about two degrees. One of these zones was observed by Dr. Gill, the other by Mr. Finlay. All the combinations of these distances in each zone were frequently observed, the observations on each night beginning and ending with observations of the extreme stars. The position angles of all the combinations were also observed, to permit the accurate projection of each distance on the great circle joining the extreme stars. The rigid reduction of these observations cannot be made till after completion of the investigation of the division errors of the scales.

Thus during a great part of the year the heliometer was in use nearly every night and every morning, and Dr. Gill found that he could not expose his eyes during this period to the additional strain of making observations for division error of the scales by day. Hence it became necessary to suspend the observations for division error in the end of February, and they were only resumed in November.

At the present rate of progress the whole of this laborious and tedious operation will be finished in February. When this is completed the error of each of the 360 working divisions will be known with a probable error considerably less than $\pm 0''\cdot 01$, for there is hardly a single instance in which the two entirely independent determinations of the error of the same division differ by more than $0''\cdot 03$.

The actual number of observations made with the heliometer during the year is as follows :—

	Pointings.
Observations for stellar parallax	1408
„ of distortion zones	616
„ scale value zones	64
Triangulations of *Iris* comparison stars	704
„ *Victoria* „	352
Parallax observations of *Victoria*, evening observations .	1858
„ „ „ morning observations	1580
Observations of standard stars in *Victoria* observations .	356
Parallax observations of *Sappho*, evening observations .	55
„ „ „ morning observations .	432
Total	7926

These figures do not include the scale-value zones and Sun diameters measured by Professor Auwers.

During the months of June, July, and August the observatory was honoured by a visit from Professor Auwers, of Berlin.

The favourable opportunity for determining the solar parallax offered by the opposition of *Victoria* and the knowledge that a single observer could not carry out, in the completest manner, the intended programme of observation, induced Professor Auwers, at the earnest request of H.M. Astronomer, to visit the Cape and co-operate in the work. Throughout the opposition of *Victoria* Professor Auwers took alternate watches of observation with Dr. Gill, and it is quite certain that during the whole period (from June 10 to August 26 inclusive) no single suitable opportunity for observation was lost.

When the favourable circumstances of parallax factor are considered, and it is further borne in mind that each of these 3438 pointings probably exceeds in accuracy one of the best meridian observations (with smaller liability to systematic error), and since an almost identical number of similar observations was obtained in the northern hemisphere, it becomes possible to form an estimate of the high value of the service which Dr. Auwers has thus rendered to science.

A large number of photographs, both of *Victoria* and *Sappho*, were obtained with the Nasmyth telescope by Mr. Sawerthal. It was found best to direct the guiding telescope upon the planet, so that upon the plate the image of the planet appears as a sharp round disc, and the images of all the stars are slightly elongated in the direction of the planet's motion. These conditions appear to be the most favourable for determining the position of the planet with least liability to systematic error. Up to the present time no information of corresponding photographic observations in the northern hemisphere has been received.

It happened that, during the period of the *Victoria* and *Sappho* observations, Mr. Finlay (the only observer who had experience in the use of the heliometer) was closely occupied, first with determinations of his personal equation relative to that of Commander Pullen, R.N., and afterwards in carrying out a chain of longitude operations on the west coast of Africa, which the completion of the submarine cable to the Cape had rendered possible. Commander Pullen had volunteered for this service upon quitting (on promotion) the command of H.M. Surveying Ship "Stork," and Mr. Finlay, from his previous experience in like work on the east coast of Africa, was selected as the co-operating observer at the Cape. Commander Pullen remained at the observatory from June 10 till July 31, to acquire familiarity with the use of the altazimuth, and to ascertain his personal equation relative to that of Mr. Finlay, both in time determinations and the observation of mirror signals. It is un-desirable to connect a cable with land lines, and the other work of the staff did not, at the time, permit the employment of a second Cape observer. Accordingly a sidereal clock, of excellent quality, was set up in the cable office, Cape Town, and this was compared with the observatory transit clock by the intervention of a mean time chronometer carried by Mr. Finlay (two miles by railway and about half a mile on foot) and compared with both clocks before and after exchange of signals. On account of pres-sure of other work on the cable four or five hours had sometimes to elapse between the two comparisons; and yet, notwithstanding the possible disturbance of the chronometer rate by transit, there is no single instance in which a discordance between the first and second comparison amounting to one-tenth of a second can be traced, so that no practical gain in accuracy would have resulted by the employment of an additional observer and the comparison of the Cape Town and observatory clocks by telegraphic signals. Although signals were exchanged and time observations made at the Cape nearly every night, only a small proportion of these exchanges could be utilised for longitude purposes on account of the cloudy weather prevalent on the west coast, so that the operations became very trying and laborious in proportion to the number of results obtained. The following stations were successively occupied by Commander Pullen :—

	Dates of Occupation.	No. of nights on which determinations of Longitude were secured.
Port Nallath . . .	Aug. 5 to Aug. 16	5
Massamedes . . .	Aug. 25 to Sept. 10	4
Benguela	Sept. 12 to Sept. 20	4
St. Paul de Loanda . .	Sept. 23 to Oct. 10	3*
St. Thomé . . .	Oct. 12 to Oct. 16	3

* Besides three incomplete determinations of which the details are not yet received.

From St. Thomé Commander Pullen made an expedition to
Brass and Opobo, in connection with preparations for a boundary
survey which he had orders to undertake at a later date.   He
reached Bonny on October 27 and was seized with malarial
fever the same day.   On October 29 he so far recovered as to
make observations the same evening and exchange longitude
signals with the Cape.   These formed the last work of his life;
a relapse followed and he died at his post on November 3.

That Commander Pullen had thoroughly mastered the use of the
altazimuth, and that this longitude series will prove to be a very
accurate and valuable one, must be evident from the following
separate results of the longitude of Loanda for the nights when
complete observations were obtained at both ends :—

	Loanda, W. of Cape Observatory.
	h m s
1889, Sept. 24	0 20 59·92
25	59·87
26	59·86

The full details of observations at other points have not yet
reached the Cape.

The field work of the geodetic survey has been resumed.   A
number of latitude stations near Port Elizabeth have been occu-
pied, and the abnormal deviations of the plumb-line there have
been investigated.   Deviations amounting to nearly $\pm 10''$ have
been observed.

Major Morris, R.E., is now engaged in the re-measurement of
a longitude chain of Bailey's triangles, connecting the southern
triangles of Maclear's work with the new system of geodetic
triangles at Port Elizabeth.

Mr. Vos, one of the Transvaal Government surveyors, has
been studying the use of geodetic instruments at the observatory
for the past six months, and leaves in a few weeks to extend the
meridian chain of triangles measured in Natal northwards to the
Limpopo.

The temptations offered by highly paid employment in con-
nection with gold mining undertakings and speculations in the
Transvaal, as well as by the new fields of enterprise in British
Zambesia, have robbed the observatory of all its old staff of
computers, so that none of the present computers have been able
to aid as observers, and from lack of suitable computers the
reductions of the observations are daily falling further into
arrear.   A full report on the subject has been submitted to the
Lords Commissioners of the Admiralty and a remedy suggested.

The observatory for the reception of the new photographic
telescope (with an admirable dome by Sir Howard Grubb) is
completed, and it is promised that the telescope itself will be
sent off from Dublin about the end of January.

The meteorological observations made in the year 1888 at

the observatory, together with those taken in different parts of the colony, have been printed in the report of the Cape Meteorological Commission.

H.M. Astronomer desires to convey an expression of his deep obligation to the directors of the many observatories who have so generously and spontaneously co-operated in the observations of *Victoria* and *Sappho* and their comparison stars.

Professor Auwers has undertaken the discussion of the results of the meridian observations, and those astronomers who have not yet communicated such observations are requested kindly to send them direct to him.

In case the reductions of any of the series of observations are not completed by the time this report is published, it is desirable that Professor Auwers be at once informed of the existence of the observations, and of the probable time when the results will reach him, in order that all existing data may be included in the final discussion.

In the case of *Victoria* especially it is found that for the most complete discussion of the whole series of observations it will be necessary to determine the relative places of the comparison stars with such precision that their errors may be regarded as insignificant, or rather as affected by very small and known probable errors. This necessity arises in great part from the fact that short periods of cloudy weather have intervened at the Cape when the skies were clear in the northern hemisphere, and *vice versâ*; so that a number of observations made in one hemisphere are preceded and followed by fine observations in the opposite hemisphere, all of the three series being referred to different stars. Such observations will consequently be lost unless the relative places of these stars are determined with very high precision. It also appears from the various series of meridian observations which have been received up to the present time that the discordances of the places of the different stars in right ascension (apart from a common correction) are so considerable that it will be necessary, in order to secure all desirable accuracy, to supplement the results of the meridian observations with a heliometric triangulation. A detailed plan for this work has been prepared, and Dr. Schur has undertaken to carry it out at Göttingen during the current year. The same will be done (if possible in duplicate) at the Cape, and Dr. Elkin also hopes to be able to include it in the programme of his year's work at Yale. If these intentions and hopes are realised the relative positions of all the stars will certainly be known within $0''\cdot 1$, and in the case of the more important stars (those which have been most frequently compared with the planet, and whose more frequent observation is provided for in the scheme of triangulation) with a still higher accuracy.

Armagh Observatory.

The refractor has been chiefly used for observations of nebulæ, but other observations have been made as opportunity offered, among which may be mentioned some physical observations of *Saturn* in the spring, and micrometric measures of the relative positions of *Mars* and *Saturn* at their conjunction on September 19.

The transit instrument by Jones, with which the Right Ascensions of the first Armagh Catalogue were made, has been thoroughly cleaned and the roof shutters repaired. It will in future be used for the time determinations. At the request of the Kew Committee the telescope of the old Kew Mural Quadrant (which had been presented to Armagh Observatory in 1841 with most of the Kew instruments) has been returned to Kew, in order that it might again be attached to the quadrant which is now preserved in the Science Collection at South Kensington.*

Meteorological observations at 9 A.M. and 9 P.M. have been taken and tabulated as usual, and the anemograph and self-recording rain-gauge kept going, and the hourly results tabulated for the Meteorological Office.

Cambridge Observatory.

The original design of obtaining at least three observations of each zone star with the transit circle is now nearly completed; so that the number of meridian observations of the zone stars is of course considerably less than in former years.

We have obtained, during the year, 441 observations of zone stars, 593 of clock stars, 109 of *Polaris*, 13 of *Victoria*, and 180 of stars selected for comparison therewith, 16 of *Sappho*, and 183 of comparison stars; making a total of 1,535 meridian observations.

The collimation, level, and nadir point have each been observed 172 times.

Reckoning from the commencement of our zone work to the end of 1889, there have been taken 51,087 observations of zone stars, and 10,493 of clock stars, in addition to observations of small planets and comets, and stars suitable for comparison with them.

The reduction of such a mass of observations has been found to be no light task for our small staff: yet the progress is satisfactory. The apparent right ascensions and north polar distances are computed up to the middle of September, 1889. The mean right ascensions and north polar distances for the beginning of each year of observation are computed up to the

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* This must be the mural arc by Sisson, made in 1770, mentioned by Montucla, *Hist. des Math.* iv. p. 377.

end of 1888. The reduction to epoch is completed in right ascension to the end of 1883, and in north polar distance to the end of 1884.

The zone stars are collected into a ledger as far as 15 hours right ascension up to the end of 1878, and this part of the work is now being pushed forward as rapidly as is practicable, preparatory to the formation of the final catalogue.

Vol. XXII., containing the observations for the years 1866–1870, is printed and will shortly be ready for distribution. Good progress has been made in the preparation for the press of the succeeding volume.

The weather has been unfavourable for observations of Comet "Brooks." We have only been able to see it on two nights, in which we obtained, with the Northumberland equatoreal, sixteen comparisons with suitable stars, and the compared stars have been observed with the transit circle.

Several applications have been made to us during the year for the places of stars included in our zone, which had been compared with comets. Except in a very few cases we have been able to supply the required information.

Dunsink Observatory.

At the date of last report the meridian observations of *Iris* and comparison stars had just been completed, but the reductions were not at that time finished. The results appeared, however, shortly afterwards in the March number of the *Monthly Notices.*

After this the working list of stars with large proper motion which has been referred to in former reports was again brought into requisition for a short time, but very little progress was made with these stars in consequence of the fact that masons were at work in the meridian room preparing a dark-room for the photographic work in connection with the 15-inch reflecting telescope, presented to the observatory by Mr. Isaac Roberts. At the end of April we received Dr. Gill's programme for observations of *Victoria* and comparison stars, and prepared to commence the work at once, but the first observations were not obtained till June 10. In this piece of work we have been very unfortunate, owing partly to the unfavourable weather and partly to several interruptions which occurred during the summer. It was discontinued at the end of August on the receipt of Dr. Gill's programme for similar observations on *Sappho* and comparison stars, which we immediately began to observe. We were able to obtain only 52 observations of 23 of the *Victoria* comparison stars and four of *Victoria*.

In the *Sappho* work, which has occupied the meridian circle since September last, we have a more creditable record, having obtained 229 observations in right ascension and declination of the comparison stars, and eight of the planet itself. With one

exception, we have observed all the stars more than once, and 24 out of the 37 have been observed as often or oftener than Dr. Gill proposed.

A great deal of time has been necessarily spent in overseeing the workmen engaged in altering the dome of the observatory, which has been hitherto occupied by the 5-inch equatoreal, in order to prepare it for the reception of the 15-inch reflector, and consequently the reduction of the meridian observations is in a somewhat backward condition, but it is hoped that the results will be ready for publication by March next.

The " South " equatoreal has been used as in previous years in searching for stars with a large parallax.

On the morning of September 20 the near approach of *Mars* and *Saturn* was observed under rather unfavourable circumstances. A few micrometric measures of the distance between the planets were obtained.

The results of the observations made in 1887 and 1888 for the purpose of determining the latitude of this observatory have been published as a paper by Mr. Rambaut in March last as the Fourth Part of Vol. IV. of the *Scientific Transactions of the Royal Dublin Society*.

Glasgow Observatory.

The operations of the Glasgow Observatory during the past year have mainly consisted in the re-observation of a select list of stars, the places of which, as given in the Glasgow Star Catalogue, cannot be satisfactorily reconciled with the corresponding places contained in Weisse's Bessel Catalogue. This work, which has been prosecuted during the last few years, is now drawing to a close, and it is expected that the results will be published before the lapse of another year.

Much of the computing force of the observatory has been devoted, as in former years, to the reduction of the meteorological observations made at the observatory with self-recording instruments during the period extending from 1868 to 1887. This work may be said to be now finished, and more time will in future be available for the legitimate work of the observatory.

Kew Observatory, Richmond.

The ordinary routine of meteorological and magnetical observations has been carried out during the year, and as usual large numbers of various scientific instruments have undergone examination.

Sketches of sun-spots have been made on 173 days, and the groups numbered after Schwabe's method.

Solar and sidereal transits have been occasionally observed as a check on the times signalled through the Post Office from Greenwich.

Observations have been made with a pair of Violle's actinometers.. These consist of two delicate mercurial thermometers, encased, the one in a well-blackened hollow metal sphere, the other in the centre of a similar sphere thickly gilded and having a highly polished surface. They are suitably mounted and taken out on sunny days, placed side by side in the open air, and then alternately exposed to the solar rays, and shielded from their action, the behaviour of the thermometers being noted.

The collection of Solar negatives from 1858 to 1872 taken at Cranford and at Kew, as well as a large number of undistributed copies of the papers on Solar Physics, by Messrs. De la Rue, Stewart, and Loewy, have been handed over to the Solar Physics Committee, with the view of their being utilised.

It was found that a much more suitable site was offered by the roof of the new building for the working of the cloud cameras; so the pedestal of the Photo-nephograph was removed from the position it formerly occupied and set up on gratings placed thereon, the necessary alterations being effected in the electrical attachments. As, however, the question of the most convenient way of utilising the cloud pictures is still under consideration by the Meteorological Council, no photographs have been taken during the past year.

The Department of Science and Art having accepted the old mural quadrant for exhibition in the science collection at South Kensington, application was made to the Governors of the Armagh Observatory for the telescope and object-glass belonging to the instrument, which had been found by Dr. Dreyer in the Armagh collection of astronomical apparatus. The Committee's request having been acceded to, the missing parts were duly received at Kew and forwarded to the Museum Galleries at South Kensington.

Liverpool Observatory, Bidston, Birkenhead.

Careful attention has been given to observations of stars with the transit-instrument, for the determination of clock errors. The Greenwich mean time has been communicated to the Port by the firing at 1^h P.M. daily, Sundays excepted, of the time-gun on the pier-head of the Morpeth dock. A large number of marine chronometers have been systematically rated in three definite and equidistant temperatures in order to ascertain their thermal errors. For some time after the re-erection of this observatory at Bidston it was the practice in summer, during the week in which the chronometers were exposed to the temperature of 55° Fahr., to place them in a cellar in the basement of the building. This was subsequently discontinued and, as no

artificial means are provided for lowering the temperature in the cases in the chronometer-room, it was decided to adopt a test ranging from 65° to 85° Fahr. during the summer months. The records showed that some chronometers had a different rate in the temperature of 55° Fahr. in the cellar, from that which they had when exposed to the same temperature in the chronometer-room. This was probably due to a difference in the hygrometric condition of the air, although the cellar appeared to be perfectly dry.

We now have a continuous record for the past twelve years of the performance, both at the observatory and also on shipboard, of the chronometers belonging to the Pacific Steam Navigation Company. It appears that when temperature corrections are applied, the rates at sea and on shore are generally nearly the same. In some instances, however, there is a systematic difference. Some chronometers gain, others lose, when at sea, on the shore rate. There is reason to suppose that such changes of rate are sometimes caused by a difference in the humidity. In steam-ships, however, when a marked constant difference has shown itself between the sea and shore rates, proper allowance having been made for thermal error, we have almost invariably found that the chronometers were exposed to an unusual amount of vibration from the machinery.

The meteorological work has been carried on as in previous years. No interruption has occurred during the past year in the records of the self-registering instruments. A report recently submitted to the Marine Committee of the Mersey Docks and Harbour Board, and now in the hands of the printer, gives some tables of results of meteorological elements deduced from observations made at this observatory during the past twenty-two years.

Radcliffe Observatory, Oxford.

During the year 1889 the attention of the observers has been chiefly directed to securing positions with the Transit Circle of all the stars down to the 7–8 magnitude which are visible between 115° N.P.D. and the Equator; but in those parts of the sky where no stars of the required magnitude are visible, stars fainter than the 7–8 magnitude have been observed, to secure the necessary zero-points for differential observations. The resulting catalogue should, with the Cape Catalogue for 1880, afford well distributed zero-points from the South Pole to the Equator.

The observing work is drawing to a close, and some advance has been made in the preparations for a General Catalogue.

The Transit Circle has also been regularly employed in observations of the Sun and Moon; of the minor planets *Victoria* and *Sappho* with comparison stars selected for observations of dis-

tances with the Heliometer. The number of transits observed during the year 1889 has been 3016, and of N.P.D. observations 2228. The Moon has been observed 62 times; the Sun 64 times; the planet *Victoria* has been observed 14 times, and 35 of the selected comparison stars have been observed three times, 2 four times, and 1 twice; the planet *Sappho* has been observed eight times, whilst of the selected comparison stars 4 have been observed three times, 8 twice, and 20 only once. The lunar crater "Mœsting A," at the request of Herr Franz, of Königsberg Observatory, has been observed eight times on the meridian.

The prevalence of cloudy weather during the months of January, April, and December seriously interfered with the observing, and rendered it necessary to introduce special morning watches to clear off certain parts of the catalogue.

The Barclay Equatoreal has been employed in measurements of the double stars ϵ^1 *Lyræ*, ϵ^2 *Lyræ*, Σ 24, 7 *Tauri*, and σ *Orionis*; in observations of Comet Barnard (1888, September 2), Comet Barnard (1888, October 30), and Comet Davidson; in a search for Faye's Comet on three nights, which was, however, unsuccessful from the faintness of the comet; in mapping stars in the neighbourhood of Tycho Brahe's Variable, and of the great nebula in *Andromeda*; in observing the occultation of *Jupiter* by the Moon on August 7, and the conjunction of *Saturn* and *Mars* on September 19; in observations of positions of the minor planet *Victoria*, the crater "Mösting A," a red star (*Lalande* 16320), and of a star occulted by the nucleus of Barnard's Comet on 1888, November 13; in an eclipse of *Jupiter's* III. satellite on August 15; and in determinations of the diameter of a new ring micrometer.

With the Heliometer attempts were made on several nights to measure the position of *Victoria*, but the faintness of the planet, its comparatively small altitude, and broken weather prevented satisfactory work.

The 7-inch and smaller Equatoreals have been used for observation of the occultation of *Jupiter*, and for examination of the lunar crater mentioned above, for subsequent identification in the field of the Transit Circle. The electric light has been successfully employed throughout the year in the illumination of the circle, field of view, clock, &c. of the Transit Circle; the scale of the Heliometer; and the wires, &c. in the field of the Barclay Equatoreal.

A discussion of the solar observations made during the years 1884–1885 has shown that the following corrections appear to be required:—

	1884.	1885.
Mean correction to adopted R.A. of clock stars	$+0^s\cdot049$	$+0^s\cdot039$
Mean correction to N.P.D. observations	$+0''\cdot260$	$+0''\cdot166$
Correction to adopted tabular obliquity	$-0''\cdot256$	$-0''\cdot157$

The mean excess of the longitudes of the Moon from Hansen's tables over the corresponding longitudes deduced from observations, when the tabular quantities are taken out for the mean solar time found from observation, as at present, amounts to $+17''\cdot4$ for the year 1889; the mean annual excess of Hansen's longitudes of the Moon over those derived from observations, whilst showing periodic fluctuations of $+1''\cdot1$ to $-2''\cdot9$ for the years preceding 1864, has since that period shown a progressive annual increase of more than $0''\cdot7$ superimposed upon the periodic change which previously existed.

The work of the observatory has been, during the past year, interrupted by the serious ill-health of two of the assistants, and also of Mr. Luff, who, after holding for nearly fifty years the office of computer, has been compelled by ill-health to sever a connection which has been honourable to himself and useful to the Observatory. But, notwithstanding these interruptions, the volume of observations for the year 1885 has been distributed; the copy for press for 1886 is far advanced; the entry into the ledgers for 1887 and 1888 is completed; and the R.A. and N.P.D. reductions for 1889 are in a forward state.

The meteorological observations have been carried on with the usual completeness, and include photographic registration of the changes of the barometer and dry-bulb and wet-bulb thermometers; and Dr. Haldane and Mr. Pembrey have made some very interesting experiments at the Observatory on the moisture of the air for a comparison with the results deduced from the dry-bulb and wet-bulb thermometers.

Oxford University Observatory.

During the last twelve months the attention of this observatory has been devoted mainly to the completion of parallax investigations relating to stars of the second magnitude through the application of photography. The results have been recently published at the expense of the University, and are contained in the third fasciculus of the observations made in this institution. They comprise thirty independent determinations of the parallax of eight stars, each referred, with one exception, to four stars of comparison. Since the publication of this fasciculus the parallaxes of three additional stars have been obtained, and in due course will be communicated to the Society. It is hoped also that by January next all stars of the second magnitude, conveniently situated at Oxford, and amounting to some thirty, will have been successfully submitted to the same process. The probable errors of these parallaxes have so far been nearly uniform and amount to about $0''\cdot03$.

The investigations thus described by no means represent the whole occupation of the observatory since the last report. Much

time has been expended on the superintendence of the practical astronomical work carried on by university students, and also on the preparation of illustrated lectures to university extension classes and to other public associations. Much time and attention have also been devoted to the adjustment and examination of several photographic object-glasses, sent for approval in connection with the projected international chart of the heavens. Although none has been yet received wholly satisfactory for the purposes intended, there is now ground for expecting final success in an undertaking which seems to be extremely difficult. Notwithstanding these serious drawbacks, it is confidently hoped that the parallactic investigations already referred to will leave their mark on the history of modern astronomy. Finally, it may be permitted here to record that the University of Oxford has conferred the honorary degree of Master of Arts on the chief assistant, Mr. Plummer, in recognition of his services to the University Observatory.

Temple Observatory, Rugby.

There has been no change in the line of work from that pursued in former years.

Mr. Seabroke has continued his measurements of the motion of stars in the line of sight, the results of which have been lately brought before the Society.

Mr Highton has been measuring double stars as usual, and it is hoped that the measurements made during the last few years will be presented to the Society in a very short time.

Stonyhurst Observatory.

In addition to the ordinary meteorological and magnetical work, which occupies a great portion of the time of the observatory staff, observations of clock stars, of the phenomena of *Jupiter's* satellites, and of occultations of stars by the Moon have been made, as in previous years.

A considerable amount of time was given to experimenting in preparation for the total eclipse of the Sun in December last, both with a 6-inch object-glass by Hilger, and with the 4-inch photographic lens lent by Captain Abney.

Drawings of the Sun showing spots and faculæ on the usual scale were made on 216 days. The Sun was examined, and notes made without drawings on three other days. The examination of the faint evanescent spots has been continued as usual. Measures of the chromosphere and prominences in the usual manner were made round the whole solar disc on seventy-seven

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days, and round a portion of the disc on two other days. Observations of the inclination or apparent drift of the chromospheric flames and smaller prominences were made on three days, and observations of the spectra of Sun-spots were made on twelve days.

Papers on Sun-spot spectra and on spots lately observed in high solar latitudes have appeared in the *Monthly Notices*, and a paper is being printed in the *Memoirs* on " Photographs and Drawings of the Sun."

The observatory has sustained, as is well known, a severe loss in the death of its director, the Rev. Father Perry. The story of his last days, as told in many of the journals and periodicals, leaves nothing to be added here in commendation of the devoted fidelity with which he completed the task entrusted to him, regardless of pain and unthinking of life. His premature death has robbed the observatory of those thoughts upon the solar chromospheric observations of ten years which were to have been put on record on his return from Salut Island, and has left the burden, without the experience, to his successor.

Mr. Common's Observatory, Ealing.

The 5-foot mirror not being found on trial to be quite satisfactory, owing to the slight ellipticity of the image of a star, probably due to the fact that the disc of glass had been resting in a sloping position for some years, was taken out in the spring and refigured and resilvered; the image now given is very much better; owing to the very bad weather very little work has however been done with it yet.

The 20-inch mirrors mentioned in the last report have been made, and two of them sent out to the Eclipse of December 22. As far as trials made before they were sent enable one to judge, such short-focus mirrors are likely to be very efficient. One is now being erected for regular use in the house lately covering the 6-inch achromatic which has been dismounted.

A new disc for the 5-foot telescope has been ordered and is expected shortly, as well as several discs of large size for plane mirrors. In view of the much better results that may be hoped for from the use of such plane mirrors as siderostats, particularly in eclipse and spectroscopic work in future, the making of plane mirrors of very large size is next to be taken up.

Mr. Crossley's Observatory, Bermerside, Halifax.

Meteorological observations at 9 A.M. and 3 P.M. have been taken daily as usual for the Registrar General's monthly report, and for Mr. Symons. A few observations of the phenomena of the satellites of *Jupiter* and *Saturn*, and a few occultations of stars

by the Moon, have also been made.   As for some years past the 3-ft. reflector has taken up much time, many changes in the mounting, &c., have been made with a view to fit it for good photographic work.   A good many photographs of the Moon and stars and a few of the *Orion* nebula have been taken during the year.

Wolsingham Observatory (Rev. T. E. Espin's).

During the past year the sweeps for new stars of the third and fourth types have been continued.   Observations have been made on forty-four nights, and ninety-three new stars of the third type and five of the fourth type have been detected. Those detected during the first half of the year were published in *Ast. Nach.* No. 2919.   Some attention has been bestowed on the spectra of the variable stars, and R *Leonis*, R *Hydræ*, χ *Cygni*, D.M. + 8°, 3780, and R *Cassiopeiæ* were found to have spectra generally similar to that of *Mira Ceti*, while in the spectra of R *Andromedæ* and S *Cassiopeiæ* the F line was found to be of remarkable brilliancy.   The latter star, which should have passed its maximum at the end of December, was probably at a maximum in the middle of November.   In the case of each of the stars with the line F very brilliant (R *Andromedæ*, S *Cassiopeiæ*, R *Cygni*), the line was seen *after* the maximum, the observations of R *Cygni* before the last maximum not showing the F line certainly bright at all.

The first proof-sheets of the new edition of Birmingham's *Red Star Catalogue* were received early in August, and were finally corrected as far as page 136 by the end of the year.   The work has been remodelled, and divided into two sections : (1) A catalogue of the places, and of observations of 766 red stars ; (2) Spectroscopic observations of the stars in the catalogue ; in addition there will be a catalogue of ruddy stars, and of stars with spectra of bright lines.

A fine sidereal clock has been presented to the observatory, and a large spectroscope, on the same principle as those in use last year, has been obtained, but a still larger one must be provided.

Dr. Huggins' Observatory.

A preliminary measurement of the photographs of the Great Nebula in *Orion*, taken during 1888 and the early part of 1889, has been made since the Report of last year, and the results have been given in a paper presented to the Royal Society (*Proc. R. S.* vol. xlvi., p. 40).   These photographs enlarge greatly our knowledge of the ultra-violet region of the spectrum of this nebula, as they show 29 new lines.   In 1882, I discovered a strong

bright line about λ 3724; this line has been seen in some of the photographs, and four new lines near it. Besides these, several new groups of lines have been found between λ 3825 and λ 4116.

In one of the photographs taken in 1888 the continuous spectra due to two of the four bright stars of the Trapezium are seen upon the plate. Across these continuous spectra at least four groups of bright lines can be detected, of which the greater number can be traced into the nebula for some distance from the continuous spectra, but in the case of the group λ 4116 to λ 4167, the lines extend but for a very little distance into the adjoining nebula. These groups of bright lines appear to show that these stars of the Trapezium are not merely optically connected with the nebula, but are physically bound up with it. In one of the photographs the strong line about λ 3724 is absent, but some new faint lines can be detected, and it seems highly probable that the spectra of different parts of the nebula are not the same in the ultra-violet region. Further information on this point is expected from new photographs which are now being taken.

In 1874 (*Proc. R. S.* vol. xxii., p. 253) I obtained by direct comparison with a thin line of lead, used as a fiducial line, a determination of the position of the principal bright line in the visible region of the spectra of the *Orion* nebula and six other nebulæ, with an accuracy certainly as great, as stated in the paper, as λ 0000·65. This relative position, translated into wave-lengths, gives for the brightest line λ 5004·6 to λ 5004·8.

The micrometric measures of D'Arrest, of Vogel, and of Copeland, agreed in assigning to this line the wave-length 5004. The wave-length of the termination of the magnesium-flame band is λ 5006·5, showing that it lies on the less refrangible side of the nebular line. Direct comparisons, made last spring under conditions in which the third line is found to coincide with Hβ, showed certainly that the 1874 determination was correct, and that the nebular line is more refrangible than the termination of the Mg flame band by about λ 0001·6 to λ 0001·9.

During the summer of last year the spectroscopes were furnished with new and sensibly perfect object-glasses by Sir H. Grubb. A re-examination with them since, of the visible spectrum of *Orion* confirmed all my earlier observations of the principal line in that it is perfectly defined at the less refrangible side, which is bright and free from flare.

Some unpublished observations on the position of the principal line in the spectrum of the aurora made in 1874, have been worked up (*Proc. R. S.*, vol. xlv., p. 430). These give for this line the wave-length λ 5571 ± 0·5. Vogel's measures in 1872 assign a position of λ 5571·3. These values agree closely with Gyllenskiöld's mean of his own and other observations from 1867 to 1884, namely λ 5570·0 ± 0·88.

Observations of the spectrum of *Uranus*, which I made in 1871, showed that it was crossed by several strong lines of

absorption, but the planet's spectrum was too faint to enable me to distinguish the Fraunhofer lines, which were presumably present. Last year, with an exposure of two hours, we obtained a photograph of the spectrum of *Uranus* which extends from a little above F to beyond N in the ultra-violet. This photograph sets the question at rest, as it shows all the stronger lines of the solar spectrum, which were recognised by direct comparison with a pair of sky-spectra, one on each side of the planet's spectrum, which were taken on the same plate. There can be no longer any doubt that the spectrum of *Uranus*, at least from a little above F to beyond N, is due to reflected solar light.

Several photographs of the spectrum of *Saturn* were so taken as to show the spectrum of the ring distinct from that of the ball. The spectra of the ring and of the ball were compared with sky-spectra taken upon the same plate. In these spectra no lines, bright or dark, other than those of the solar spectrum could be detected.

Photographs of *Vega* with long exposures have shown, as was to be expected, that the limit of light in the ultra-violet region which can reach us through the Earth's atmosphere, as shown by photographs of stellar light, is the same as was known to exist for the solar spectrum.

At this observatory the light of *Vega* is abruptly weakened at λ 3000, and sensibly extinguished about λ 2970. Solar spectra taken under similar circumstances show approximately the same limits of absorption and of extinction.

Four photographs, with very long exposures, have been obtained of the spectrum of the great nebula in *Andromeda*, and the same number of the spectrum of the Dumb-bell nebula; but the results, which are new, are reserved for the present. We shall probably wait for further photographs to be taken next autumn before entering upon a discussion of the photographs we have already obtained.

Rousdon Observatory, Devon (Mr. C. E. Peek's).

During the past year 159 nights have been clear, wholly or in part; 23 variable stars are under constant observation. No change has taken place in the staff or instruments.

Mr. Isaac Roberts' Observatory, Maghull.

The photographic work done at this observatory during the past twelve months is not large in quantity, owing to the sky being seldom clear. After careful watching each night, it was found that only four intervals, each of two hours' or longer duration, occurred between February 4 and November 20, 1889.

Since November there have been five intervals suitable for photographic work, and the results obtained will be communicated to the Society.

In consequence of the normally cloudy state of the sky here, an observatory and residence are being erected on Crowborough Hill, in Sussex, whither, in the course of next summer, it is intended to transfer the instruments; and it is expected (in reliance upon the result of extensive inquiries made and reports received) that a better record of stellar photographic work may be shown in future from thence.

The following is a list of the enlarged photographs which have up to this date been presented to the Society, and described in the *Monthly Notices*; and selections of six of them have been presented to about seventy observatories, and to astronomers in several parts of the world:—

	Plates.
1886, August, Stars in *Cygnus*	4

	h	m		°	′
R.A.	19	45.	Declination +	35	30
„	19	55.	„	37	45
„	20	4.	„	35	30
„	21	2.	„	38	12

	Plates.
November, Nebulæ in the *Pleiades*	2
1887, January, „ „	1
Nebula in *Orion*	1
The minor planet *Sappho*	3
June, Cluster M. 13 *Herculis*	2
July, Nebula M. 57 *Lyræ*	2
August, Dumb-bell nebula, M. 27 *Vulpeculæ* ...	1

	h	m		°	′	
· Stars in *Cygnus*:
R.A.	19	45	Declination +	35	30 ...	1

	Plates.
1888, October, Dumb-bell nebula, M. 27 *Vulpeculæ* ...	1
Nebula in *Andromeda*	1
December, „ „	1
Nebulæ in the *Pleiades*	1
1889, March, Nebula in *Orion*, photographic analysis	7
Nebulæ M. 81 and 82 *Ursæ Majoris* ...	1
April, Spiral nebula, M. 51 *Can. Ven.*	1

The Earl of Rosse's Observatory, Birr Castle.

During the past year a series of sketches of the Milky Way, on which Dr. Boeddicker had been engaged for several years, were completed and combined in a set of four—one of them an index-map on about half the scale of the other three—which are now lying, pending publication, in the rooms of the Society, and have been noticed elsewhere. This work from its commencement has taken very much more time than had been anticipated, and from affording useful occupation only in the intervals amid the proper work with the instruments of the Observatory, came to monopolise in a very great measure the time and energy of the observer.

The complete reduction of the heat-observations during the lunar eclipse of January 28, 1888, has since been resumed, and is expected to be soon complete. Their publication will bring to a close our lunar radiation work with the Thomson reflecting galvanometer and thermo-couple, as it does not seem probable that the work can be further pursued with advantage with our present instrumental means. The subject, however, may be well worth pursuing with improved appliances.

Some desultory photographic work has been carried on at intervals, but it becomes pretty clear that, without considerable modifications, our instruments cannot successfully compete with more modern instruments, though of smaller size, which have been specially designed for this new work, and the wonderful success obtained with the latter leads one to pause and ask, Can the pencil of the draughtsman be any longer profitably employed upon nebulæ as seen through the 6-foot when photography, to say the least, follows so closely on his heels?

The 3-foot equatoreal seems capable of adaptation to photography, but the 6-foot mounting, though most convenient for the purpose for which it was designed, the re-examination of the objects in Herschel's Catalogue with greater "space-penetrating power," can only, we think, be adapted for photographing nebulæ by entirely re-mounting it. This would, obviously, be a task not to be undertaken without the most careful consideration.

The readings for the Meteorological Office have been continued as usual.

Colonel Tomline's Observatory.

The same course of work has been pursued at the Orwell Park Observatory as in previous years. All the comets of the year (with one exception) have been observed upon each occasion when the observation was possible; one observation only being made upon each night, and that one consisting generally of eight separate comparisons of the comet with a single neighbouring star.

While sweeping for Comet *b* 1889 (Barnard, June 23) on July 1 the declination axis of the equatoreal became immovable, and the work was consequently interrupted for some weeks, unluckily at a time when it would otherwise have been actively and advantageously pursued. The telescope was dismounted on August 19, and the axis ground to the bearing by Mr. Simms, since which time the working has been entirely satisfactory.

The following table gives a summary of the observations that have been made :—

Comet.	No. of Observations.	Total number of separate Comparisons.	Limiting dates of Observation.			
Barnard (*e* 1888)	12	83	Jan.	1 to July	22
Barnard (*f* 1888)	12	93	Jan.	1 ,, Mar.	25
Barnard (*b* 1889)	8	53	Sept.	5 ,, Oct.	31
Brooks (*d* 1889)	31	233	Aug.	29 ,, Dec.	25
Brooks (companion to *d*)	13	50	Sept.	16 ,, Nov.	12
Davidson (*e* 1889)	20	140	Aug.	29 ,, Nov.	13
Swift (*f* 1889)	3	23	Dec.	11 ,, Dec.	24
Borrelly (*g* 1889)	1	9	Dec. 25		
Total observations of Comets	100	684			
Observations of faint or unknown Comparison Stars	21	93			

On August 25, after an illness of eight months, Colonel Tomline died at his residence in London. He had maintained the observatory for rather more than fifteen years, but, recognising that his successor might not be willing to follow in his footsteps, he had already made some preparation for definitely closing the establishment.

The work for the future will therefore be carried on only so far as to complete the series of cometary observations at present begun, or at most such work only will be undertaken as may be completed and reduced within a very limited time. It is uncertain at present whether the means will be found to enable the observer to bring the work, which is still unpublished (*i.e.* nearly the whole of that enumerated above), into a form suitable for publication, but every effort will be made to do so.

Hong Kong Observatory.

The electric time-ball has been dropped as usual at 1 P.M. The second standard clock is expected here in May next, and a chronograph has been ordered subject to the approval of the Astronomer Royal.

Sir W. Thomson's automatic tide-gauge has been marking continuously, and three years' trace is now available. Hourly readings have been finished for the first two years. They are made by two native assistants, whose readings are compared, and, in case of doubt, the trace is inspected.

Meteorological observations and researches, daily weather-reports and storm-warnings, were continued as in previous years. The spectroscopic rain-band was observed every morning, and the strength of the band is found to indicate rain, and particularly great thunder-storms, beforehand. Magnetic observations were made as in previous years. Some eclipses and occultations were observed with the Lee Equatoreal.

The fifth annual volume was published early last year. The printing of the sixth volume is not yet begun. It will probably be published in the course of next year, and will contain the hourly tidal readings in an appendix.

Melbourne Observatory.

The ordinary routine work, astronomical, meteorological and physical, has been carried on during 1889 as usual. The meridian work includes observations of stars selected from the Berlin *Jahrbuch*, as well as of *Sappho* and *Victoria* and comparison stars, according to Dr. Gill's programme.

The great reflector has been dismantled for the greater part of the year for the purpose of refiguring and repolishing the two four-feet mirrors, which had become so tarnished by nearly twenty years' use as to be unfit for delicate observations. This task has been of greater difficulty than was anticipated, but after numerous failures and partial successes one mirror was satisfactorily completed early in December, and it is expected the telescope will shortly be in use again.

In the extra-meridian work of the year, which has nearly all been done with the 8-inch equatoreal, is a preliminary spectroscopic survey of southern stars as a help to a more careful and systematic examination with the large telescope. Some advance sheets of this work have already appeared in the *Monthly Notices*.

Preparations are in progress for carrying out the Melbourne share of the astrophotographic charting of the heavens. A new building for the telescope has been erected close to, but unattached to the south end of the main building, and contains on the ground floor a well-fitted photographic room, store room, &c., above which is the telescope chamber, covered by an 18-feet hemispherical dome of wood sheathed with copper. Everything is ready for the reception of the telescope now being constructed by Sir Howard Grubb, and which it is expected will arrive within a month or two.

The routine work of the Observatory comprises transit-circle observations of fundamental N. A. stars, standard circumpolar stars, and special lists of comparison stars for comets and for other purposes, extra-meridian observations of all comets not in a good position for northern observatories, daily sun photographs, magnetographs of magnetic variations, monthly determinations of absolute magnetic values, and the usual work in local and inter-colonial meteorology, time distribution, rating chronometers, &c.

The annual visitation of the Board of Visitors was held on September 3.

Sydney Observatory.

The year 1889 has been here very unfavourable for astronomical work. Continued cloudy and unfavourable weather rendered observation nearly impossible. An estimate of it may be formed from the fact, that on only one night in the year was definition sufficiently good for measures of close double stars, and on only six nights good enough for stars under $2''$ distance. Fifty-six double stars were measured with the large equatoreal, fourteen observations were made of Comet Davidson on five nights, Comet Barnard 1888, September 2, was observed on four nights, the careful examination and delineation of *Jupiter*, which has been regularly carried on since 1876, was continued. Twenty-three coloured drawings of the planet have been made and two sets of micrometer measures of positions and dimensions of the various belts made. Frequent observations of the magnitude of η Argûs have been made. Mr. J. E. Davidson reported to Sydney Observatory on July 21 the discovery on the previous evening of the comet which bears his name. On July 22 the comet was observed here and a cablegram sent to Europe of its discovery. Regular work has been kept up as weather permitted with the Transit Circle.

Number of determinations of Collimation				...	...	304
„	„	„	Level...	...	...	410
„	„	„	Azimuth	...	...	216
„	„	„	Nadir	...	...	304
Number of stars observed in R.A. ...				...	...	2,171
„	„	„	N.P.D.	...	...	812

During the year the determination of longitudes in conjunction with the trigonometrical survey has been continued as in previous years, and to this work fifty-two of the available observing nights have been given: the longitudes of seven inland towns have in this way been determined.

During the year preparations have been made for the astro-

photographic work, and preliminary arrangements have been made with the view of placing this instrument out of the city smoke on an elevation of 620 feet above the sea, in a most favourable position for such work; it is easily accessible by railway and is eleven miles inland from the present observatory. The observatory for this instrument has been made of thin corrugated iron in order to secure rapid assimilation of temperature, and the whole of the mounting and clock-work for the telescope have been made in the colony. The object-glass has been made by Sir Howard Grubb. The Astronomer Royal has kindly consented to test it before it is sent out, and it is expected to arrive in February or March, when the experimental work will be begun.

The polar-axis tube, &c., of this astro-photographic telescope will weigh about two tons; the form is similar to that in use in the Paris Observatory, and unusual weight has been given to the moving parts in order to avoid tremors in the instrument itself.

The illumination of the large equatoreal micrometer and circles by incandescent lamps worked by E.P.S. cells charged by means of a gas engine and dynamo continues to give great satisfaction; a similar method of illumination has been applied to the $7\frac{1}{4}$-inch equatoreal with equally satisfactory results, and cells and a more powerful gas engine have been provided to extend this method to the Transit Circle and to supply electricity for the various chronographs and recording apparatus, &c.

During the year the micrometers for the $11\frac{1}{2}$-inch and $7\frac{1}{4}$-inch equatoreals have been altered, so that now one incandescent lamp turning with the moving parts throws two rays of light on to the wires, giving a perfectly steady and satisfactory illumination, the amount of which is completely under control at the eye end of the telescope.

All the instruments are in good order, the self-recording and general meteorological work have been continued as usual, two weather maps are issued each day, and meteorological observations are received and published from 1,050 stations in this Colony.

One remarkable effect of the weather upon astronomical work cannot be passed over: from May 24 to 29 rain fell to the extent of 20 inches at the observatory, and from 20 to 26 inches over all the district to west of it for 30 miles. When the storm was over the level error of the Transit Circle was found to be 6″ less than it was before. Such a change would be produced if the weight of the rain were sufficient to cause a sinkage in the surface of the ground west of the observatory. The level, I may add, took about six months to recover its normal position. The fact is worth recording without assuming that we have proof that the weight of rain on the ground did cause the change of level. The pier of the Transit Circle rests on a hill of solid sandstone, and all the surrounding circumstances are opposed to the supposition that the change of level was due to an effect in the immediate locality of the instrument.

Mr. Tebbutt's Observatory, Windsor, New South Wales.

In consequence of the large proportion of cloudy nights during the year 1889 the work done at this observatory is rather limited. The instrumental errors of the 3-inch transit have been as steady as in the preceding year, and 833 star-transits, including azimuth stars, have been observed for local time. The extra-meridian work is as follows:—

Thirty-two disappearances of stars at the Moon's dark and two reappearances at the bright limb were observed—namely, twenty-eight with the 8-inch, four with the 4½-inch, and two with the 3¼-inch telescopes. Of the thirty-two stars occulted twenty-six have been identified.

Phenomena of *Jupiter's* satellites were observed chiefly with the 8-inch telescope as follows : Transit ingress, I.2 ; II.2 ; III.1 ;. IV.1. Transit egress, I.3 ; II.1 ; III.2 ; IV.1. Occultation disappearances, I.1 ; II.1. Occultation reappearances, I.3. Eclipse disappearances, I.3 ; III.2. Eclipse reappearances, I.1 ; II.1 ; III.1.

Observations were made with the filar micrometer on the 8-inch equatoreal of *Juno* on February 22, March 3, 5, 6, 11, 15, 16, 17, 21, April 1, 2, embracing 119 comparisons and 9 comparison stars; *Hebe* on September 1, 4; 7, 8, 9, embracing 45 comparisons and 7 comparison stars; and of *Flora* on August 10, 12, 13, 14, 19, 20, 21, 23, embracing 81 comparisons and 10 comparison stars.

The following comets were observed with the square bar-micrometer, the 4½-inch equatoreal being employed on August 14, 15, and the 8-inch equatoreal on all the other dates : Comet I. (Barnard 1889), on January 2, 4, 5, 6, June 23, 26, 29, July 1, comprising 70 comparisons and 8 comparison stars; Comet IV. (Davidson 1889), on July 23, 24, 27, 28, 29, 31, August 14, 15, comprising 62 comparisons and 14 comparison stars; and Comet V. (Brooks 1889, July 6) on October 25, 28, comprising 10 comparisons and 3 comparison stars. Brorsen's periodical comet was searched for with the help of Dr. E. Lamp's ephemeris in No. 2933 of the *Astronomische Nachrichten* on December 21, 25, but without success. The well-known binaries *p Eridani* and *γ Coronæ Australis*—the latter at the suggestion of Mr. Gore—have been measured, and the magnitudes of *η Argûs* and *R Carinæ* determined on several occasions.

The usual 9ʰ A.M. meteorological observations have been made throughout the year with great regularity, and upwards of five months' records of the times and magnitudes of the local tides have been secured by means of a self-registering tide-gauge.

Finally, all the preceding observations have been made, and the greater part of the reductions executed, by the director himself.

Erratum in last Report: For *μ Argûs* read *η Argûs.*

NOTES ON SOME POINTS CONNECTED WITH THE PROGRESS OF
ASTRONOMY DURING THE PAST YEAR.

Discovery of Minor Planets.

The following six minor planets were discovered in the year
1889 :—

No.	Name.	Date of Discovery, 1889.	Discoverer.	Place of Discovery.
282	Clorinda	Jan. 28	Charlois	Nice
283		Feb. 8	,,	,,
284		May 29	,,	,,
285		Aug. 3	Palisa	Vienna
286		Aug. 3	Charlois	Nice
287	Nephthys	Aug. 25	Peters	Clinton

The Comets of 1889.

At the beginning of the year three comets were visible, viz.
the periodical comet of Faye, of which an admirable series of
observations was made at the Lick Observatory, extending from
August 1888 to the following February, and two others, both
discovered by Mr. Barnard. Of these two comets, that detected
on 1888 September 2, was observed up till the end of October
1889, and the other, first seen on 1888 October 30, remained
under observation till May. The discussion of the observations
of the former of these two comets shows that the orbit is hyper-
bolic, and the long period over which the observations extend
makes this conclusion trustworthy. There is, too, some reason
to believe that this deviation from the parabola is due to an ap-
proach of the comet to the planet *Uranus* in 1882. During the
year no less than seven comets have been discovered.

I. On 1889 January 14 Mr. Brooks, of Geneva, N.Y., dis-
covered a faint telescopic comet in Sagittarius, just before sun-
rise, which, owing to its unfortunate position, and the increase
of moonlight, was never seen again.

II. Mr. Barnard added another to his many cometary dis-
coveries by detecting, on March 31, a small faint comet in

Taurus. It was described as 10″ in diameter, and with a tail some 15′ long : but it always remained an inconspicuous object, being at a great distance from both Sun and Earth. The comet was observed throughout April, in May and June it was too near the sun for observation, but towards the end of July (after perihelion passage) it again became visible, and was followed up till November. The observations are fairly represented by a parabola.

III. On June 23 Mr. Barnard discovered another comet. It was an extremely faint nebulosity, about 2′ in diameter, and, growing fainter, was seen but for a few weeks, being lost early in August. The observations show some deviation from parabolic motion, and elliptic elements have been computed by Dr. Berberich, who assigns a period of 128 years to the orbit; but this discussion is not yet definitive. The faintness of the comet easily explains the fact that it has not been observed at any earlier apparition.

IV. A second comet, discovered by Mr. Brooks on July 6, possesses considerable interest. This object when first seen was rather faint, and with a short wide tail, and up to the end of July did not undergo any great change in appearance. On August 1, however, Mr. Barnard telegraphed that the comet had separated itself into several distinct parts, thus exhibiting the same feature of ready disintegration which had characterised the great comet of September 1882. The continued observation of the component parts has on this occasion, however, been more complete, the large telescopes of the Vienna and Lick Observatories having been employed in a careful and continuous study of the structure of the comet. The details of these observations will be found given in the *Ast. Nach.*, Nos. 2919, 2922.

The orbit also is interesting. The small inclination and direct motion suggested a periodic character, which calculation has established : the period, though at present a little doubtful, will not differ much from seven years. The orbit at aphelion approaches very closely to that of *Jupiter*, and in 1886, from March to July, according to Mr. Chandler, the comet's distance from the planet did not exceed one-tenth of the Earth's mean distance from the Sun. It is, therefore, probable that the elliptic character of the orbit was assumed during that time, in which case the resemblance between this orbit and that of Barnard, 1884, II., must be regarded as accidental.

V. A naked-eye comet, first seen by Mr. Davidson, of Queensland, on July 19, who described it as exhibiting a bright nucleus of about the fifth magnitude, with some extension of nebulosity, but no tail. When seen on July 22 at Melbourne, however, a tail of about 30′ long was visible, but the comet had then passed its greatest brilliancy and was rapidly fading. Its motion carried the comet from *Centaur*, where it was first perceived, through *Libra* and *Serpens* to *Hercules*, so that observations in the northern hemisphere were easily possible. It was followed to

the end of November, but the observations are fairly represented by a parabola.

VI. On November 16 Mr. Swift discovered a faint comet in *Pegasus*, but increasing slightly in brilliancy. It presented the ordinary cometary appearance, without tail or pronounced nucleus. The deviations from the parabola were soon sufficiently marked to show ellipticity, and a period of about seven years has been assigned to the orbit. The period is, of course, somewhat un-certain, and at the end of the year the comet is still under observation.

VII. The catalogue of cometary discoveries for the year was completed by M. Borrelly, of Marseilles, who on December 12 saw a faint comet in *Lyra*. This, like the last mentioned, is still being observed, and is increasing in brilliancy, the maximum intensity of light being reached on January 24. There is at present no reason to suspect ellipticity. W. E. P.

The Corona of 1889.

In the year 1889 there were two successfully observed total solar eclipses. The first, on January 1, was visible in California, and the considerable resources of the fixed observatories of the United States were drawn upon unsparingly to make the occa-sion productive; while at the same time the army of amateurs anxious to assist to the best of their ability was most skil-fully organised. A large number of beautiful photographs of the corona were obtained, especially by the parties from the Harvard College Observatory (who used, among many other instruments, a 13-inch telescope), and from the Lick Observa-tory. Many spectrum-photographs were also taken, in some of which a staining of erythrosin was used to render the plates sensitive in the red and yellow. The amateurs made drawings under the printed and circulated directions of Professor D. P. Todd and others. Special mention should, however, be made of the Amateur Photographic Association, whose members, to the number of twenty, undertook a special research with small instruments, dealing with the progressive differences in result obtained with different exposures.

The eclipse of December 22 was not so well adapted for ob-servation. Available stations were Trinidad, Cayenne and the neighbourhood in French Guiana, and Cape Ledo in South Africa. The Royal Astronomical Society sent observers to Cayenne, and to Cape Ledo, equipped with similar instruments, viz. a pair of 4-inch lenses and of 20-inch short-focus mirrors, with which to photograph the corona; but bad weather at Cape Ledo prevented any advantage resulting from the *double* ex-pedition. A large party from the United States who were stationed at Cape Ledo were also disappointed of results. At

the Salut Isles near Cayenne, totality was observed in a fine interval between storms. Father Perry and his assistant carried out the programme drawn up for them with complete success : but the expedition resulted in the death of Father Perry. He died from dysentery within a few days of the eclipse. Professors Burnham and Schaeberle from the Lick Observatory also obtained coronal photographs at Cayenne, and M. de la Baume Pluvinel from Paris made successful observations. At Trinidad clouds prevented observation.

The photographs of the corona at both eclipses show a remarkable similarity to one another and to those of the 1878 eclipse. It seems to be now well established that the corona of a sun-spot minimum is of a distinctive character; its boundary is very roughly similar to that of a rather flat, empty cotton-bobbin with feathery bunches protruding from wide axial openings. The broad groove for the cotton is not always represented on both sides of the Sun's disc. On January 1, 1889, and December 22, 1889, it is more strongly marked at the eastern limit. The flatness and parallelism of the top and bottom of the bobbin are often surprisingly definite for so flimsy a structure as the corona; but on December 22 there is a marked exception, the south-east boundary of the equatoreal portion being nearly normal to the limb and inclined at about 45° to the direction of the south-west boundary. It is divided from the feathery structure at the poles by a remarkably definite rift, prominent in all the photographs. The limit of the photographed corona is apparently about a diameter from the limb, though eye observation claims a much greater extent for the corona. The 20-inch mirrors taken out by the English expeditions of December 22 were constructed to determine whether this discrepancy was due to want of power in photographic apparatus. The mirrors had an effective aperture of 15 inches and a focal length of only 45 inches, so that they may be taken to fairly represent a great increase in photographic power. But the plates taken with them at Salut show no greater ' extension ' than those taken with a 4-inch lens. This result, however, does not appear to be conclusive; the failure of the 15-inch mirror to show more than the 4-inch lens may apparently be due to some accidental and purely instrumental circumstance, for it affects the short exposure photographs, as well as the longer, and is really a failure in instrumental power, and not in the light of the object photographed. It seems probable that in the very damp weather, during which the eclipse took place, a film of dew may, in spite of every precaution to the contrary, have settled on the mirror and decreased its brilliancy. We have, therefore, no conclusive evidence against the future possibility of photographing these faint outer portions of the corona, if they exist.

All hopes of detecting changes in the corona during the two-and-a-half hours which elapsed between the occurrence of totality at Cayenne and at Cape Ledo, by comparison of the two sets of

photographs, were destroyed by the failure at the African station.

Most of the plates used at these eclipses were fitted with standard squares on Captain Abney's principle, allowing of the subsequent determination of photometric intensity. There has not yet been time to obtain definite results.

The photographs of the spectrum taken on January 1 show it to be very simple in character. According to Mr. W. H. Pickering it contains little besides the hydrogen lines; but here also detailed measures will require more time.   H. H. T.

Professor Harkness' Researches on the Masses of Mercury, Venus, and the Earth.

" There are in existence not less than fourteen determinations of the mass of *Mercury*, and not less than nineteen determinations of the mass of *Venus*; but the separate values differ largely among themselves, and it is impossible to deduce any trustworthy means from them. A re-discussion of the original data seems the only satisfactory course, and that is the object of the present paper."

From the available materials Professor Harkness deduces four groups of equations for determining v, v', and v''; where these quantities (referring respectively to *Mercury*, *Venus*, and the *Earth*) are connected with the masses of the planets in the usual way—viz., $m = m_0 (1 + v)$, m being the true, and m_0 the assumed, value of the mass. The first group of equations depends on the motions of the nodes of *Mercury* and *Venus*, and is deduced from a discussion of the transits of these planets across the Sun, together with meridian observations of *Venus* made at Greenwich, Paris, and Washington during the years 1836 to 1871. The second, third, and fourth groups of equations are taken from the *Annales* of the Paris Observatory, and have been derived: 1. From the secular motions of the perihelion, inclination, and node of *Mars*. 2. From a near approach of *Mars* to $\psi^2 Aquarii$ cn October 1, 1672; the longitude of *Venus* deduced from Horrox's observations of the transit of December 1639; the longitudes of *Venus* obtained from Bradley's meridian observations; the longitudes of *Venus* obtained from meridian observations between the years 1766 and 1830; the latitudes of *Venus* resulting from the observations of the transits of 1761 and 1769; and the latitudes of *Venus* obtained from the Greenwich meridian observations made between the years 1751 and 1830. 3. From observations of the Sun. It will, of course, be understood that in his re-discussion of these materials Professor Harkness uses the modern, and presumably improved, values of the masses of the exterior planets, and other numerical data that enter into the equations. The degree of accordance obtained by Professor Harkness can be most clearly seen by setting down the separate

values of ν, ν', and ν'', deduced from each of the above-mentioned groups of equations. The values of ν are—

$$-0.566867 \pm 0.427$$
$$-0.265744 \pm 1.511$$
$$-0.619604 \pm 0.09692$$
$$-0.770229 \pm 0.317.$$

The values of ν' are—

$$-0.012330 \pm 0.00575$$
$$-0.055742 \pm 0.03576$$
$$-0.052249 \pm 0.04755$$
$$+0.003688 \pm 0.00749.$$

The values of ν'' (deduced from the second and third groups only) are—

$$+0.148078 \pm 0.03847$$
$$+0.089161 \pm 0.01301.$$

The final values were deduced from the simultaneous solution of all the equations in the various groups, which were first reduced to a uniform standard of weight. The results for the reciprocals of the masses are—

Mercury	$= 8704559 \pm 1724742$
Venus	$= 404681 \pm 2134$
The Earth	$= 332768 \pm 1778.$

The value of the Solar Parallax resulting from this value of the mass of the Earth in conjunction with the best modern values of the length of the seconds-pendulum, the length of the sidereal year, and the size and figure of the Earth, is $8''.795 \pm 0''.016$.

Professor Harkness' paper is published in the *Astronomical Journal*, No. 194. In a subsequent No. of the *Journal*, Professor Harkness points out that the value of the mass of the Earth given above really includes that of the Moon. Making allowance for this, the resulting value of the Solar Parallax is $8''.759$.

Dr. H. Struve's Researches on Saturn's Satellites.

Dr Hermann Struve has published in the current volume of the *Astronomische Nachrichten* (Nos. 2945-46) an important paper entitled "Preliminary Results from the Observations of the Satellites of *Saturn* made with the 30-inch Refractor." In a former volume of the *Nachrichten* the same astronomer discusses a series of comparative observations of the satellites *Iapetus* and *Titan*, and another series of comparative observations of *Titan* and *Rhea*, made with the 15-inch refractor of the Pulkowa Ob-

servatory.   Recognising the systematic errors to which micro-metric observations are liable when it is attempted to compare a satellite directly with the limb of the planet, the author prefers to measure the relative position of the two satellites rather than the position of each with reference to *Saturn*.   In a separate pub-lication entitled " Supplement I. to the Pulkowa Observations," the author gives a more complete discussion of his observations of *Iapetus* and *Titan* and those of *Titan* and *Rhea*, as well as of a shorter series of observations of *Rhea* and *Dione*, all of these observations being comparative, and made according to the plan above mentioned.   From the equations of conditions given by these observations, Dr. Struve deduces the corrections of the assumed elements of the satellites' orbits by the method of least squares.   He also finds the value of the mass of *Saturn* $= \frac{1}{3498}$ of that of the Sun, which agrees closely with that found by Bessel.

While the observations of the satellites of *Saturn* with the 15-inch refractor were directed mainly to the determination of the mass of *Saturn* and the elements of the orbits of the outer satellites, the observations with the 30-inch refractor with which we are now concerned aim at the determination of all the re-maining elements of the Saturnian system, and with reference to the objects to which they are directed may be divided into three groups.

(1) The observations for the determination of the orbits of *Rhea*, *Dione*, *Tethys*, *Enceladus* and *Mimas*, the inner satellites of *Saturn*.

(2) The observations of *Hyperion*, made partly in comparison with the disc of the planet, and partly in comparison with *Titan* and *Iapetus*.

(3) The determination of the dimensions of the planet, and of the system of rings, and the angle of position of the line of the ansæ.

The author has made observations with these objects in view during the last four oppositions of *Saturn*, and he has now pub-lished some preliminary results relating to the first of the above-mentioned groups which possess considerable interest.   It shows the great light-collecting power of the 30-inch refractor that in all the observations of the satellites, with the sole exception of those of *Hyperion*, it was found possible to make the measures in an illuminated field.

The magnifying power employed was 515.

This paper deals only with the orbits of *Rhea* and *Tethys* from measures connecting the two.   In the reduction of the measures of distance made with the Repsold wire-micrometer, the value of one revolution of the screw at $t°$ centigrade is taken to be

$$= 12''\cdot7835 - 0''\cdot00025t.$$

The periodical errors of the screw are found to be quite insigni-ficant.

With respect to the deduction of the elements of the satellites' orbits, substantially the same course is adopted as in the case of the observations with the 15-inch refractor. The polar co-ordinates directly observed are changed into rectangular co-ordinates, and these last are then compared with those calculated from approximate elements. In the comparison with observations for both satellites, circular elements in the plane of the ring (this last being assumed according to Bessel's determination) were taken as a starting point. The longitude and mean motion for *Rhea* were taken according to the author's own observations with the 15-inch, and for *Tethys* according to the older observations, while the mean elongations were calculated with the value of *Saturn's* mass $= \frac{1}{3500}$ of that of the Sun.

The assumed elements of the two satellites' orbits are the following; the epoch being 1886 March 22·0, mean time at Greenwich:—

		Tethys.	Rhea.
Longitude	E	165°30′·3	140°57′·3
Node	♌	168°0′·0	168°0′·0
Inclination	i	28°10′·0	28°10′·0
Mean Tropical daily motion	λ	190°·69820	79°·690096
Mean Elongation	a	42″·609	76″·169

(for $p = 9·53887$)

In the calculations for the last epoch 1889, corrected longitudes were employed, viz. for *Tethys* $dE = -40′·0$ and for *Rhea* $dE = -8′·0$.

The author then gives a comparison between the results of observation and calculation. During the first three oppositions the observations were made by himself exclusively, but during the last opposition half of the observations were made by Herr Renz. Since the observations with the 15-inch refractor have given no sensible eccentricity for the orbit of *Rhea*, this orbit has been taken as circular, while for *Tethys*, where the older observations had indicated a small eccentricity, the quantities *e* sin P and *e* cos P have been introduced as unknown quantities.

Besides these the author introduces the two nodes, inclinations and longitudes of the epoch, as well as the mean elongation of *Rhea*, that of *Tethys* being supposed known, so that there are nine unknown quantities to be determined for each separate opposition.

The representation of the observations by means of the corrected values of the elements found from the equations of condition leaves nothing to be desired. The differences between the calculation and observation in 281 equations only in five cases amount to so much as 0″·2.

From the periodic time and mean elongation of *Rhea* the reciprocal of the mass of *Saturn* is found to be 3493·0±0·89,

but a small systematic error in the measurement of distances would of course greatly affect this result.

The comparison of the elements obtained for the different years shows in reference to the longitudes of *Rhea* a good agreement, whereas the longitudes of *Tethys* show considerable differences which are not to be removed by an alteration in the assumed mean motion.

The author's observations in this respect are confirmed by those of Herr Bohlin, who deduces from the discussion of an older series of observations the existence of a periodical term in the longitude of *Tethys* which he represents empirically by $A \sin \mu t$.

The eccentricity of *Tethys* is found from the equations of condition to be a small quantity of the same order as that of *Rhea*, and as the orbit of the latter was assumed to be circular, the eccentricity deduced in the case of *Tethys* can have little or no significance.

The fluctuations in the planes of the orbits of *Tethys* and *Rhea* shown by the solution of the equations of condition for the several years merit special attention.

These, in the first place, make possible a good determination of the position of *Saturn's* equator. It follows from a known proposition in the theory of perturbations, that the planes of the orbits of the inner satellites, while preserving a nearly invariable inclination with respect to *Saturn's* equator, must move on this latter plane so that the velocity of the node is nearly uniform, supposing, as is the case in the Saturnian system, that the compression of the planet is the chief cause of perturbation.

In fact, the results of these observations show that the elements of *Saturn's* equator may be so taken that the above condition for the satellites *Rhea* and *Tethys* is very nearly fulfilled. Thus for *Tethys*, if Bessel's determination of the elements of position of *Saturn's* equator be taken, it is found that the discrepancies in the values of the inclination of the orbit to the equator shown in different years considerably surpass the residual errors of the elements, and cannot be explained by the perturbations caused by the other satellites. If, on the other hand, proper corrections are applied to Bessel's elements, and the inclination of the satellite's orbit to *Saturn's* equator be taken $= 65''\cdot1$ there will be found a satisfactory agreement between the results of the several years.

Similarly, the elements of the orbit of *Rhea*, which have been obtained by means of the old refractor, can be shown to be consistent with each other in the several years if we suppose the inclination of the orbit to *Saturn's* equator to be $20''\cdot5$.

The author gives the following corrected elements of *Saturn's* equator referred to the equinox of 1886·2 : longitude of the node on the ecliptic $167°53'\cdot6$, inclination $28°\cdot2''\cdot0$.

From the longitudes of the node of the orbit of *Tethys* on

Saturn's equator, the author deduces that the yearly retrograde motion of the node on this equator is $72°\cdot8$.

Similarly, for the node of the orbit of *Rhea*, the yearly retrograde motion of the node is found to be $10°\cdot2$.

The motion of the nodes of *Tethys* and *Rhea* possesses a special interest through a comparison of it with the mean motion of the peri-Saturnium of *Titan*, for which the later observations, after allowing for precession and the perturbations caused by the Sun, have given the approximate value $\Delta P = 1800''$ $= 0°\cdot500$ per year. From this the author deduces an approximate value of the constant of compression for *Saturn*.

On the hypothesis already adopted by the author, that the masses of the satellites stand in a simple relation to their brightness, and relying on the photometric measures of Professor Pickering and the sufficiently well-known value of the mass of *Titan* $= \frac{1}{4700}$, he finds that the spheroidal form of the planet and the mass of the rings will account for about $62°\cdot2$ of the observed motion of the node of *Tethys*, and that the action of the other satellites will probably account for $3°\cdot7$, so that nearly $7°$ would be left unaccounted for. Similarly, the author estimates that the annual motion of the node of *Rhea*, due to the effect of the compression and the rings, would be about $8°\cdot1$, and that the effect of the perturbations caused by the other satellites would be about $1°\cdot1$, making altogether $9°\cdot2$, while the observations give $10°\cdot2$.

It will be observed that the difference between the calculated motion of the node and that deduced from the observations, is in both cases in the same direction, and the author thinks that at least in the case of *Tethys* the difference is larger than the possible uncertainty of the latter quantities.

The author is inclined to think that the difference between the observed and calculated values of the motion of the nodes may be explained in great part by supposing that the mass of the rings amounts to about $\frac{1}{300}$ part of the mass of the planet, but when the discussion of the observations of *Dione, Enceladus,* and *Mimas* is completed, we may expect that further light will be thrown on this point. **J. C. A.**

Professor Auwers' Researches on the Sun's Diameter.

Professor Auwers has continued his researches on the value of the Sun's diameter deduced from various series of observations, to some of the results of which attention has been directed in a former Report (*Monthly Notices*, vol. xlviii. p. 206). The paper now under consideration is No. III. of the series, and is published in the *Sitzungsberichte* of the Berlin Academy. It contains a discussion of the Greenwich transit observations of the Sun's diameter made during the years 1765–1810, by Maskelyne and

his assistants, and is carried out in that thorough and pains-
taking manner which is characteristic of all Professor Auwers'
work.   It will be remembered that, a good many years ago,
Lindenau discussed Maskelyne's observations of the Sun, and
the present investigation has been undertaken chiefly with a
view to the extension of Lindenau's researches, so as to exhibit
the results of a much larger number of observations.   Instead,
therefore, of contenting himself with making use only of those
transits of the Sun's first and second limbs which were observed
over the same threads, as Lindenau did (thereby restricting
himself to but a small portion of the existing materials), Pro-
fessor Auwers has determined afresh the intervals of the transit
threads from appropriate star-transits, and has thus been able to
utilise every observation in which transits of both limbs of the
Sun were observed for determination of the horizontal diameter.

The observations under discussion are necessarily divided
into two portions, *i.e.* those made before and after July 1772.
At this date a new achromatic object-glass of 2·6 in. aperture was
fitted to the transit instrument in place of the old 1·6 in. non-
achromatic lens which was used previously.   At the same time
a new and more powerful eyepiece was brought into use.   From
his discussion of the observations made by Maskelyne and his
assistants with the old object-glass, Professor Auwers finds that
there is an apparent annual inequality in Maskelyne's values of
the Sun's horizontal diameter, the observed diameter being
greater than the mean in winter and less in summer (the range
being about o⁸·05), and that this is borne out by the assistants'
observations, so far as any result of this kind can be deduced
from their somewhat meagre contributions.   With regard to
progressive change during the years under consideration (1765–
1772), with the exception of the first two years—when the ob-
servers were new to the work, and made the diameter much too
large—there is no fluctuation that would not be covered by the
accidental errors of the observations.   During the years 1772–
1810, with the new and improved instrumental means, Maske-
lyne's observations still show an annual inequality of about the
same magnitude and in the same sense as those made with the
old object-glass.   But it is somewhat remarkable that the assis-
tants' observations made during this period show an inequality
in exactly the opposite direction, *i.e.* they make the diameter
smaller in winter than in summer, the range being about o⁸·05.

The progressive change, as exhibited in Maskelyne's obser-
vations made during the period 1772–1810, is also remarkable.
Professor Auwers finds that the corrections to the diameters as
given in the *Tabulæ Regiomontanæ* can be represented by the for-
mula $-o^s \cdot 243 \mp o^s \cdot 015 (t - 1790 \cdot 5)$, where the upper sign is applic-
able up to 1790·5, the lower after that date.   Instead, therefore,
of Maskelyne's observations giving progressively smaller values of
the Sun's diameter during his whole observing life, as has hither-
to been supposed, Professor Auwers' very exhaustive discus-

sion leads us to this result : that after the first two years (which
gave a very large value), the observed diameter remained nearly
constant for the period 1767–1772, then during the years 1772–
1790 the diameter was continually decreasing, lastly from 1790–
1810 the observations gave a diameter continually increasing.
The minimum value in 1790 was 31′ 58″·13—about 1″ smaller
than the value obtained from modern heliometer measures. The
assistants did not individually observe through a sufficiently long
series of years to afford a complete check on the results obtained
from Maskelyne's observations as to progressive change in the ob-
served value of the Sun's horizontal diameter. Professor Auwers
has, however, discussed their observations thoroughly, deter-
mined their "personal equations " referred to Maskelyne's values
of the diameter, and, generally, left nothing undone to render
complete his discussion of the Greenwich series of diameters ob-
served during the years 1765–1810.

The Moon's Physical Libration.

When, half a century ago, Bessel was enabled, by getting
sufficiently free from other more pressing investigations, to em-
ploy the Königsberg heliometer for the purpose of investigating
the Moon's physical libration, he entrusted the making of the
observations to one of his assistants, H. Schlüter, who had
already given proof of great skill and diligence by his observa-
tions for the determination of the parallax of 61 *Cygni* and
of the positions of the stars in the *Pleiades*.   After having
accumulated a long series of sets of measurements extending
over two years and a half, from April 29, 1841, to November 6,
1843, Schlüter fell ill and died, at the early age of 28 years, in
March 1844, predeceasing Bessel by two years.   At the end of
1844 the observations for the Moon's libration were resumed by
Wichmann, and continued till January 1846.   When, after
Bessel's death, Wichmann undertook the investigation and pre-
pared his paper "Erster Versuch zur Bestimmung der physi-
schen Libration des Mondes aus Beobachtungen mit dem Helio-
meter " (published in vols. 26 and 27 of the *Ast. Nach.*), he
confined himself at first to the reduction of his own observations
and the determination of their results, and was the more justi-
fied in doing so, as the final results of the whole series of
measurements could only be arrived at on condition that suffi-
ciently approximate values of some of the unknown quantities
had already been secured.   It was, no doubt, Wichmann's inten-
tion to undertake the very laborious task of extending his inves-
tigation, so as to found it upon the whole series of available
observations; but other occupations, and, later on, his failing
health, did not allow him to accomplish more than part of the
task.   The results of Schlüter's measurements remained con-

sequently unknown, but lately they have been brought to light
and investigated by Dr. Julius Franz in a very meritorious
paper, published in vol. 38 of the *Königsberg Observations* : "Die
Konstanten der physischen Libration des Mondes abgeleitet aus
Schlüter's Königsberger Heliometer-Beobachtungen." After
an exposition of the theory of the physical libration, in which he
introduces some modifications and simplifications of the method
followed by Wichmann, Dr. Franz explains the successive steps
in the complicated reduction of the observations and the instru-
mental constants he has adopted ; and, taking due advantage of
Wichmann's preparatory computations, he deduces from the 158
sets of measurements the selenocentric ecliptical longitudes and
latitudes of the observed spot Mösting A. In computing the
corresponding tabular longitudes and latitudes and their differ-
ential coefficients, he has the advantage of starting with fairly
approximate values, not only of the selenographical co-ordinates
λ, β of the spot and of the inclination I of the Moon's equator,
but also of the constant f, the ratio of the differences of the
Moon's principal moments of inertia, which must be sufficiently
well known, if the necessity for repeating a considerable portion of
the computations is to be avoided. The comparison of the cor-
responding values of the selenocentric longitudes and latitudes
furnishes, then, the 306 equations of condition, from which the
corrections of the assumed values are obtained. Omitting, at
first, those terms of the physical libration which are independent
of the inequalities of the Moon's revolution, Dr. Franz deduces
the following values :—

$$\lambda = -5\overset{\circ}{} \; 10\overset{'}{} \; 19\overset{''}{}0 \pm 7\overset{''}{}9 \qquad I = 1\overset{\circ}{} \; 31\overset{'}{} \; 22\overset{''}{}1 \pm 7\overset{''}{}3$$
$$\beta = -3 \; 11 \; 24\cdot0 \pm 5\cdot5 \qquad f = 0\cdot4878 \pm 0\cdot0278$$

the probable error of the deduced selenocentric longitudes being
$96''\cdot1$, and of latitudes $61''\cdot4$, or geocentrically $0''\cdot44$ and $0''\cdot28$,
the smallness of which testifies to the skill and care with which
Schlüter's observations were made. Dr. Franz then introduces
in the equations of condition those terms of the physical libra-
tion which are independent of the Moon's revolution, but repre-
sent the remnants of oscillations, which in some early state of
the Moon's rotation may have been very considerable. The
computation of these terms, however, shows that they are too
small to be determinable from the available observations. As
Schlüter's series is the only one, which is spread over a full
period of the chief of these oscillations, this result is of consider-
able weight. Disregarding, therefore, these terms as insensible,
Dr. Franz adopts the previously mentioned values of λ, β, I, f
as the final ones, and deduces from them the values u, w, w'' of
the Moon's physical libration as affecting the longitude, node,
and inclination :—

$$u = +133''\cdot3 \sin g' - 21''\cdot8 \sin g + 17''\cdot6 \sin 2\omega$$
$$\sin I \cdot w = +11\cdot0 \sin 2(g+\omega) - 95''\cdot4 \sin g$$
$$w'' = +11\cdot0 \cos 2(g+\omega) - 95\cdot4 \cos g$$

where, in conformity with Hansen's tables, g' denotes the Sun's mean anomaly, g that of the Moon, and ω the departure of the Moon's perigee from the node.

Dr. Franz concludes his explanations with the proposal of determining the Moon's place by substituting observations of the spot Mösting A for those of the limbs.

When, in his paper "Ueber den astronomischen Gebrauch der Mondkarte," published 1837, in No. 337 of the *Ast. Nach.*, Mädler recommended the substitution of observations of spots for those of the limbs, he suggested Triesnecker B as the most suitable spot for the period from first to last quarter, and the spots Messier and Flamsteed for the earlier and later parts of each lunation. In 1855 and 1856 the method was tried in longitude determinations in the United States, and there is a paper about it to be found in the report of the Coast Survey for 1856, Appendix No. 25, "Report to the Superintendent of the Coast Survey, by Dr. C. H. F. Peters, on the method of substituting a lunar spot instead of the Moon's limb, in transits for determining the difference of longitude," the spot used being Messier, which is observable from about the fourth to the seventeenth day of each lunation. Mr. Neison has preferred Triesnecker A (or, as he has renamed it, Murchison A), which he calls in his book, *The Moon*, . . . "perhaps without exception the most distinct and conspicuous object within ten degrees of the centre of the Moon, and peculiarly well adapted to serve as a standard point for the origin of lunar measures and for the investigation of the Moon's real libration; its only rival is Mösting A, which, if perhaps slightly brighter, is surrounded by a bright region and is, moreover, slightly larger." According to a statement to be found in the *Selenographical Journal*, vol. 3, p. 84, Professor Winnecke had selected, presumedly for some good reason, the preceding of two small spots, south following Triesnecker, the chosen spot being in selenographical longitude $+2° 22'$ and latitude $+3° 19'$; but nothing further has been published about the observations there mentioned. Mösting A has at present the advantage that its selenographical co-ordinates are more accurately determined than those of any other lunar spot.

A. M.

The Orbit of Sappho.

During the past year Dr. R. Bryant has published the results of an investigation of the orbit of *Sappho* (80) from observations extending over the whole period from its discovery in 1864, to the opposition in 1888. This great task of calculation he has performed single-handed. Finding that a first solution correcting the elements only of *Sappho's* orbit left considerable errors, he has endeavoured to remedy this by introducing a correction to the mass of *Jupiter*, the solution of the equations leading to a change

in this element, which, while very large, is of no great weight. In seeking to mend matters Dr. Bryant was led, by a remark of Professor Adams, to consider the elements of *Sappho* as liable to a progressive change due to the action of the asteroids as a whole. The introduction into the equations of condition of terms involving the annual amounts of these changes was followed by a new solution for corrections. There now remained three normal places which stood out prominently in error. One of these has been brought into near accordance with computation by the discovery of an error in its deduction : and the other two depend on very few observations, each at one place, and during very few days, so that errors affecting them are probable. Dr. Bryant's enormous task could hardly be expected to have been quite free from errors of computation ; he may be congratulated on having arrived at so fair a result, and we may hope that the revised ephemeris, which he promises for 1889, will be accurate enough to reduce the observations of *Sappho* which have been made during the opposition, in order to determine the solar parallax.

The Greenwich Ten-Year Catalogue for the Epoch 1880.

This catalogue was published towards the close of the year 1889, and is a complete summary of the stellar work with the transit circle at the Royal Observatory, Greenwich, in the years 1877–1886. It contains observations of practically all stars to the sixth magnitude, inclusive, which had not been observed at Greenwich since 1860 ; besides many others such as fundamental stars, stars near the zenith and horizon suitable for discussion of refraction, stars with large proper motion, close circumpolars, &c., which are continually observed at Greenwich, and stars required for comet or planet comparison, or other special purposes. The observations have been reduced to 1880·0 with Auwers' proper motions. The places of clock stars have been discussed in a separate investigation, by including only those cases where the same observer made observations for more than twelve hours, so that the mean clock correction for the group may be considered free from systematic errors in the assumed places of the clock stars. The corrections to the catalogue places thus indicated are found to be very small, and have not been applied. The correction to epoch for the catalogue was determined by a careful discussion of the solar observations made in the same ten years, and found to be insensible. For this discussion the observed N.P.D.'s of the Sun in the various years were all reduced to one system of R−D, flexure, co-latitude, and refraction corrections, the systems actually used in the various years having undergone several changes ; and the refractions were finally corrected to correspond with the readings

of a more freely exposed thermometer than that previously used.

Similar systematic corrections in N.P.D. have been applied to the stellar observations where necessary, so that the catalogue is essentially homogeneous.

The observations of 691 circumpolar stars above and below the pole are compared and discussed in the introduction to the catalogue. The co-latitude found from the comparison of N.P.D.'s is 38° 31′ 21″·935, differing by only +0″·035 from the adopted value.

Cases of individual discordances have been examined with the greatest care, and every effort has been made to exclude mistakes in the reductions.

The total number of stars in the catalogue is 4059.   H. H. T.

Standard Catalogue for the Southern Zones of the Astronomische Gesellschaft.

This catalogue, containing the places of 303 stars for the epoch 1885·0, has been prepared by Professor Auwers for use in the reduction of the zone observations extending from − 2° to − 23° declination to be carried out under the auspices of the *Astronomische Gesellschaft.* It is published in the *Astronomische Nachrichten,* Nos. 2890–91. The places of 135 of the stars occurring in the catalogue have been derived from the author's Fundamental Catalogue (Publ. *Ast. Gesell.* xiv. and xvii.), the Cordoba General Catalogue, a MS. Catalogue supplied by Dr. Gill, the Washburn Observations, and observations made at the U.S. Naval Academy at Annapolis.   The places of the remaining 168 stars have been derived from the Karlsruhe Observations, Becker's Catalogue of Bradley Stars, and the Cape Catalogue for 1880, checked by later Cape observations. In general the proper motions adopted are those of the author's Catalogue, deduced from his re-reduction of Bradley's observations, but in certain cases a new determination of proper motion from all available materials was made.   Professor Auwers considers that these star places, although merely provisional, are of considerable accuracy; they certainly agree well with those of the Fundamental Catalogue and other standard catalogues with which they have been compared for check.   The system of right ascensions adopted is that of the Fundamental Catalogue; that of the north polar distances is identical with Professor Auwers' Mean System of N.P.D's. (*Ast. Nach.,* No. 1532), or with the system of the Fundamental Catalogue (which depends on Pulkowa) with the correction +0″·50−0″·02 × δ°.   The catalogue before us has evidently been prepared with care and skill, and by facilitating the reduction of the zone observations between − 2° and − 23° declination will, we hope, ensure the successful completion of that important work.

The Brussels Catalogue of 10,792 *Stars for the Epoch* 1865.

The principal object of this extensive work has been to deter-
mine the positions of stars having, or which have been suspected
of having, large proper motions.   It also contains the places of
certain other classes of stars, such as multiple stars, moon culmi-
nators, &c.   Stars down to the tenth magnitude appear to have
been included in the work.   The observations extend from
1857 to 1878, and were made with the transit instrument and
mural circle of the Brussels Observatory, which were not altered
in any way during this long period.   The catalogue consists of
two parts : the first gives the positions of the fundamental stars
which have been used in the reductions ; the second (forming
the general catalogue) gives the positions of 10,792 stars of the
classes referred to above.

With regard to the reductions, it may be sufficient to say that
the clock errors and rates have been determined from observations
of fundamental stars, below $50°$ $51'$ north declination, given in
the *Nautical Almanac.*   The "zenith points" of the circle have
been determined by reflection and direct observations or from
observations of stars given in the *Nautical Almanac.*   In those
cases in which star places have been taken from the *Nautical
Almanac,* it does not appear that any attempt has been made to
reduce the different systems used in that work during the period
1857–1878 to uniformity.   The reductions of the apparent places
to the beginning of the year of observation have been made by
means of "star constants" which, for stars of less than $80°$
declination, have been computed *only once* during the period
under consideration, whilst for stars occurring in the British
Association Catalogue, and of less than $60°$ declination, the star
constants given in that work have been used.   With regard to
the reduction of the observations of each year to the adopted
epoch 1865·0, the precessions have been computed for each year
for the fundamental stars, whilst for the General Catalogue the
precessions for 1865 have been used throughout, thus neglecting
the effect of secular variation.   No correction for proper motion
has been applied to the observed places of stars in the General
Catalogue.   In the case of the Catalogue of Fundamental Stars, it
is stated on page xii. of the introduction that no correction for
proper motion has been applied, whilst on page xiv. it is stated
that the proper motions of Auwers' Fundamental Catalogue have
been used in the formation of these star places.   It is, therefore,
doubtful what has really been done.

It should, however, be pointed out that M. Folie states in the
preface to the work that it is proposed to publish a supplement
to this catalogue, giving corrections to the star places on account
of inaccuracies in the reductions as they have actually been
effected.   This, doubtless, refers (amongst others) to the points

noticed above, but it would have been a much more convenient arrangement to have published these corrections as part of the catalogue itself, instead of letting them appear in a subsequent volume, without which the star places of the catalogue as it stands are not, we fear, of sufficient accuracy for the purposes of refined investigation.

The work before us is the outcome of an immense amount of labour, and gives the places of many stars which have received little or no attention at other observatories.

The Williams College Catalogue of North Polar Stars.

Professor Safford has recently published a catalogue of right ascensions of stars within 25° of the north pole, which he describes as an "attempt to strengthen the weak point of all our Standard Catalogues—the right ascensions of polar stars." The observations collected and discussed in this catalogue were made with the Repsold meridian circle of the Williams College Observatory (aperture of object-glass 4½ inches) during the years 1882–1887. The results have been reduced to the epoch 1885·0 and exhibit the mean right ascensions of 261 stars deduced from observations made both above and below the pole. It has been Professor Safford's intention to make this catalogue mainly differential, the instrumental corrections depending on 11 stars of Auwers' Fundamental Catalogue (Publ. *Ast. Gesell.* xiv.), and the clock-errors being deduced mainly from the star places of the *Berliner Jahrbuch*. In the plan of the observations the use of Pond's method was entirely avoided, *i.e.* no star was considered as *determined* on any evening which had been required on the same evening for the instrumental corrections. During the year 1887 a chronograph was brought into use, being employed only for the observation of stars below 80° of declination. The instrumental corrections were still determined, as before, by the closer stars and the older method of observation, using clock corrections obtained by the same method. It was found that no large difference existed between the results of the two methods below 80°, when this course was followed. A very full and careful discussion of his results leads Professor Safford to the following conclusions :—

"First, that it is highly conducive to accuracy, systematic as well as in detail, to base a catalogue of polar right ascensions upon standard places in all hours of right ascension, rather than upon double transits alone. Second, that the introduction of meridian marks according to Struve (long-focus object-glasses, also suggested by Rittenhouse) is a great advantage to the primary catalogues. Third, that the eye-and-ear method should be retained as the standard within a narrow rather than a wide range of polar distance. Fourth, that modern meridian instru-

ments are subject to irregular small changes of position, which are not direct functions of the temperature ; so that in all differential work it is better to keep a close watch upon clock-rate and instrumental adjustments rather than to trust the instrumental zero-points for more than two hours without re-determination of the most essential. Fifth, that the right ascensions here given are reasonably accurate. Sixth, that a thorough comparison of the chronographic and eye-and-ear method within a wide range, both of magnitude and declination, is desirable."

Orbits of Binary Stars.

Computers of double-star orbits have reason to be thankful to Professor Glasenapp, Director of the Imperial University Observatory, St. Petersburg, for bringing into notice some very elegant formulæ for determining the true orbit of a binary star. He follows the usual graphical method of obtaining the best possible apparent ellipse, and then, instead of determining the elements of the apparent orbit, he proceeds by a neat and simple method to evaluate the coefficients in the general equation of the ellipse,

$$ax + \beta y + \gamma x^2 + \delta xy + \epsilon y^2 + 1 = 0 ;$$

assuming $y = 0$, this reduces to $ax + \gamma x^2 + 1 = 0$. the roots of which represent the ordinates of the intersection of the ellipse with the axis of x, which can be measured with a scale on the graphical representation of the apparent orbit. If we call these values x_1 and x_2 we get

$$a = -\frac{x_1 + x_2}{x_1 x_2} \text{ and } \gamma = \frac{1}{x_1 x_2}.$$

Similarly if $x = 0$, β and ϵ are found, and then by measuring the co-ordinates of two other points δ may be obtained. To determine these coefficients by the method of least squares is a long process. The elements of the true orbit are now determined directly from these coefficients by means of the elegant and singularly simple formulæ of M. Kowalsky. These were buried in a Russian paper published in the Proceedings of the Kazan Imperial University, and were practically useless until unearthed by Professor Glasenapp. In a pamphlet dedicated to M. Otto Struve, on the occasion of the Jubilee of the Pulkowa Observatory, Professor Glasenapp exhibits the orbits of OΣ 387, OΣ 149, OΣ 489, OΣ 413, OΣ 4, and OΣ 20, as obtained by this method. He also gives a list of personal equations in observing position-angles, and a table of the elements of the orbits of all OΣ stars hitherto calculated.   T. L.

Variable Stars.

Mr. Chandler, to whose valuable catalogue of variable stars a reference was made in the last Annual Report, has continued the study of the phenomena presented by these objects, and has communicated the interesting results he has obtained to Gould's *Astronomical Journal* (Nos. 186 and 193), the journal in which his catalogue was itself published.

Taking his catalogue of 1888 as a basis, Mr. Chandler proposed to himself an investigation of the "relations which spring from the fact of periodicity; namely, the co-ordination of the lengths of the periods with the numbers of the variables, with their colour, with their range of fluctuation, with the forms of their light curves, and with the irregularities of their periods and of their light-variations," an investigation which led, briefly, to the following results :—

In regard to the first point he finds an excess of short periods, namely those under 20 days, while for the long-period variables a well marked maximum is indicated as lying about a period of 320 days. Turning to the question of colour, the evidence is distinct that the redness of a star is a function of the length of its period. The redder the tint, the longer the period. In respect of range of fluctuation, while it is probable that there is a dependence of range upon the duration of the period, the relation is not one of strict proportionality of range to period. Coming to the relations between the forms of the light curves and the periods, the author has tabulated the "Ratio of Increase to Decrease," taking unity to represent an equality in this respect, and values less or greater than unity to represent a greater or less rapidity of increase than decrease. From this it appears that "the average ratio for stars with periods less than 100 days is about 0·65 ; between 100 and 200 days it is slightly in excess of unity; it then declines as the periods lengthen, at first gradually, but in the neighbourhood of a year with extraordinary suddenness, recovering as quickly, until it again exceeds unity in the group of extremely long periods." In the case of the numerical laws of the perturbations of the periods, Mr. Chandler remarks that his researches are not yet complete, but that broadly, in the case of long-period variables, the irregularities are periodic in their nature, and in the case of those of short-period, secular and exceptional.

Mr. Chandler has handled his subject with great skill and ingenuity, and his papers are in every way worthy of careful examination and study.   G. K.

M. Radau's Memoir on Astronomical Refraction.

M. Radau has recently published, in Tome xix. of the *Annales* of the Paris Observatory, a very complete memoir on the important subject of Astronomical Refraction, which deals with the theoretical as well as the practical side of the question, and contains complete tables in a convenient form suitable for the actual computation of refractions.

In the first chapter of the memoir the author discusses the constitution of the atmosphere, and the law according to which the temperature and density of the air diminish as we proceed upwards from the Earth's surface.   M. Radau also discusses the influence of humidity on refraction, utilising, in this connection, the experiments of MM. Fizeau and Jamin.

In Chapter II. we find an analysis of the fundamental formulæ of the theory, as well as a discussion of the numerical value of the constant of astronomical refraction : the author adopting Bessel's value of the constant in the construction of his tables.

Chapter III. contains the explanation of the mathematical processes by means of which the definite integral which expresses the refraction is transformed so as to allow of its value being calculated numerically.   For the relation between temperature and density the author adopts the hypothesis of Ivory, which makes the decrease of temperature proportional to that of density; the ratio of the two decrements being then constant along the path of the ray of light.   This ratio, of course, varies from time to time, and enters into the refraction formulæ as a quantity depending on the readings of the thermometer and barometer taken at the time of observation.

In Chapter IV. M. Radau explains the construction of the tables which accompany the memoir.   These appear to be arranged in a very convenient form for practical use, and to be sufficiently extended to obviate the necessity of troublesome interpolation, even at large zenith distances.   The principal novelties are the correction for humidity, referred to above, and the correction for effect of gravity on the height of the barometer, which, of course, varies with the latitude.

Without actual trial it would be impossible to say whether these refraction tables are superior to those of Bessel for practical purposes : they are certainly more conveniently arranged for large zenith distances.   But it must not be forgotten that the chief difficulty in determining astronomical refractions is a practical one, i.e. the difficulty of determining the temperature of the air which is applicable at the time of observation.

*Professor Pritchard's Researches in Stellar Parallax by the
aid of Photography.*

In No. III. of the Astronomical Observations made at the
University Observatory, Oxford (Clarendon Press, 1889), Pro-
fessor Pritchard has given us a complete account of the very
interesting series of Parallax Observations that he has made by
photography. There can be little doubt that for the delicate
work of stellar parallax as applied to the fainter stars the photo-
graphic method must ultimately prevail over all other methods
by micrometers or by heliometers. It is impossible to study the
present volume or to examine the plates themselves without
finding ample evidence in support of this conclusion. In the
first place, as Professor Pritchard remarks, the photograph will
just as easily provide us with four comparison stars as with two,
and the subsequent measurements upon the plate afford results
which are to say the least quite as good as the very best measure-
ments of star distances that can be obtained by any other method.

Nearly half of the work before us is occupied with a most
elaborate series of measurements of 61 *Cygni* with four com-
parison stars. As both components of the double have been
independently considered, we have, in fact, eight measurements
of the parallax. This renowned star has been attacked by
almost every investigator of star distances, and opinion was
gradually converging to the belief that the parallax of 61 *Cygni*
could not be far from midway between $0''\cdot 40$ and $0''\cdot 50$. But
when the high authority of Professor Asaph Hall could be cited
as evidence that the star must be nearly twice as far off as these
figures would indicate, it became manifest that there was still
ample room for such a research as that of Professor Pritchard.

To show the value of the photographic method as applied at
Oxford, we may cite the following table of results :—

Star's Name.	Mag.	Relative Annual Parallax.	Probable Error of Parallax.	Probable Error of One Complete Measure of Distance.
		61₁ *Cygni.*		
		$''$	$''$	$''$
D.M. + 37° No. 4189	7·9	+ 0·4294	± 0·0162	± 0·091
„ + 38° „ 4336	8·8	+ 0·4414	± 0·0222	± 0·115
„ + 37° „ 4175	9·0	+ 0·4448	± 0·0212	± 0·102
„ + 38° „ 4348	9·5	+ 0·4193	± 0·0182	± 0·089
		61₂ *Cygni.*		
D.M. + 37° No. 4189	7·9	+ 0·4250	± 0·0176	± 0·099
„ + 38° „ 4336	8·8	+ 0·4508	± 0·0191	± 0·100
„ + 37° „ 4175	9·0	+ 0·4320	± 0·0190	± 0·088
„ + 38° „ 4348	9·5	+ 0·4303	± 0·0178	± 0·104

These figures seem to justify the remark that "the four comparison stars probably belong to a remote system not containing 61 *Cygni*." The smallness of the probable error speaks sufficiently for the accuracy of which the method is capable.

The other stars discussed in this volume are μ *Cassiopeiæ*, *Polaris*, a *Cassiopeiæ*, β *Cassiopeiæ*, γ *Cassiopeiæ*, and a *Cephei*, among which β *Cassiopeiæ* alone seems to have a parallax which attains the value of a tenth of a second. The table p. 137, in which all the results are epitomised, gives incidentally a striking illustration of the advantage which the photographic method has over that by micrometers. In the latter case 300″ is about as great a distance as can be conveniently measured, while the photographic plates enable distances of even 1380″ to be dealt with. Of course there would be no point to be made in this respect in favour of the photographic method over that by the heliometer.

It seems that this work, so successfully carried out by Professor Pritchard and his able assistants at Oxford, must be the initiation of a new method in the study of the important subject of star distances.   R. S. B.

Determination of the Motions of Stars in the Line of Sight by means of Photography.

Professor H. C. Vogel, who was one of the first to confirm the recession of *Sirius* from the solar system after the original observations in 1868, has recently entered upon, with the assistance of Dr. Scheiner, an investigation of the motions of all the brighter stars visible at Potsdam, by the method of Photography. Those observers who have worked at these delicate comparisons by eye will be the first to welcome a method which diminishes greatly the uncertainties which may come in from atmospheric disturbances.

The consistent agreement of Professor Vogel's preliminary results seem to show that the difficulties of obtaining trustworthy simultaneous photographs of the brighter stars, together with a terrestrial bright line for comparison of position, have been successfully overcome, and that his method is capable of considerable accuracy, and that consequently the results which we may look for from Potsdam will have great value, and be deserving of confidence.

As it was important to obtain the spectrum on as extended a scale as possible of a large number of stars without an exposure inconveniently long, Professor Vogel wisely determined to limit the part of the spectrum on the plate to the region for which the ordinary silver bromide gelatine plates are most sensitive— namely, to a small distance on each side of G, from λ 451 to λ 417; and to employ as the line of comparison the hydrogen line H γ, which falls near G.

One of the most important conditions to be observed in such an investigation is the absolute rigidity of the comparison spectrum relatively to that of the star. To avoid the danger of shift from flexure, in different positions of the telescope, when the comparison spectrum is connected directly with the spectroscope or its attachments, it had been found desirable to introduce the artificial spectrum within the tube of the telescope itself, and further to diminish the risk of parallactic displacement of the artificial spectrum, to place the source of light at some distance from the slit. Professor Vogel places his vacuum-tube at a distance of 40 cm., and though it is not actually fixed within the telescope-tube, it is so close to the end of the tube as to be practically free from the possible effects of flexure in the spectroscope and its attachments. These have been constructed, both in respect of material and of form, so as to give great stability to the whole instrument, which is attached to the eye-end of the Potsdam refractor.

The optical part, constructed by Steinheil, consists of two Rutherfurd prisms, of very transparent glass. The objectives of the collimator and of the camera are made as thin as possible, and are corrected for G. The apparatus is fully supplied with the means for all the necessary adjustments, not only in respect of focus, but also of the direction of the optical axis of the collimator with that of the telescope. A small breadth, usually from 0·2 to 0·3 mm. is given to the spectra by such an alteration of the clock motion as is needful to make the star's image move slowly through the necessary distance within the slit.

The effects of temperature changes have been carefully examined, and tables of corrections provided by which the necessary alterations of focus can be made, when the change of temperature during the exposure, usually about one hour, exceeds 2°; within this limit no sensible falling off of sharpness can be detected. Practically some time is required for a change of external temperature to reach the prisms, and special precautions are taken that change of temperature does not affect the position of the hydrogen line relatively to the star's spectrum. The slit is usually made very narrow, from ·02 to ·03 mm., corresponding to an angular value of 10 to 15 seconds.

The spectra, which are about 3 to 4 cm. in length, are measured under a suitable microscope with a magnification of from 7 to 35 times.

Within this small region of the spectrum, in the case of Capella, no fewer than 250 lines have been measured, and the coincidence of nearly all of them with solar lines confirms the conclusion already arrived at by Huggins in 1882, that this star is almost identical in composition and in present temperature with our Sun. Up to the present time about 170 photographs have been taken of about 50 stars. These photographs have been measured, but some time must elapse before the final conclusions as to the motions, and changes of motions, of the stars are

reached. The results in the case of five stars have been given provisionally; these show the close agreement of photographs taken on different days, and the high degree of accuracy to be expected from this work. The motions are given in geographical miles, + represents recession, and − approach.

a Aurigæ.

1888, Oct. 22	+ 3·5	1888, Dec. 1	+ 3·1
24	+ 3·6	13	+ 3·2
25	+ 3·4	1889, Jan. 2	+ 3·3
28	+ 3·2	Feb. 5	+ 4·0
Nov. 9	+ 3·7	Mar. 6	+ 3·8

a Tauri.		*a Ursæ Minoris.*	
1888, Oct. 28	+ 6·4	1888, Nov. 14	− 3·2
Nov. 10	+ 6·7	Dec. 6	− 3·8
Dec. 4	+ 6·3		

a.Persei.		*a Canis Minoris.*	
1888, Dec. 5	− 1·5	1888, Dec. 8	− 1·5
10	− 1·6	29	− 1·6

It is of interest to compare these results with those obtained under the great difficulties of eye observation at Greenwich:—

	Vogel, English Miles.	Maunder, English Miles.		Vogel, English Miles.	Maunder, English Miles.
Capella	+ 17·1	+ 22·5	*a* Persei	− 7·2	− 22·5
Aldebaran	+ 30·3	+ 31·6	Procyon	− 7·2	+ 3·8

A result of great interest, which had been indeed already foreshadowed by the Greenwich Observations, has come out of Professor Vogel's photographs, in the case of the variable star *Algol.* Six photographs of *Algol* taken in 1888 and 1889 show a distinct change of motion to be connected with its light period, namely that before minimum it is receding at the rate of 24·4 English miles per second, while after the minimum has been passed the star approaches us with the velocity of 28·6 miles per second. From these velocities it follows that the system of *Algol* is approaching our system at the rate of 2·3 miles per second, and that the visible star has a velocity in its orbit of 26·3 miles per second.

From these results, which Professor Vogel wishes to be regarded as provisional only, he deduces the following approximate data of the *Algol* system :—

Diameter of *Algol*	...	...	...	1,061,000 English miles.
Diameter of dark companion		...	...	830,300 ,,
Distance of centre	...	...	...	3,230,000 ,,
Motion of *Algol* in orbit		...	...	26·3 miles per second.
Motion of companion	...	...	...	55·4 ,,
Mass of *Algol*	...	...	...	...	$\frac{4}{5}$ of Sun's mass.
Mass of companion	...	...	...	$\frac{2}{9}$,,
Translation of System towards the Sun				2·3 miles per second.

Professor Vogel has assumed that both bodies have the same density, so that their masses are directly as their volumes. Professor Vogel is not unaware of many points of difficulty in connection with this hypothetical state of things in the system of *Algol*, and its relation to the known phenomena of the star's light-changes. He refers to one point, namely, the apparently great difference of temperature of two bodies not differing more greatly in mass, one intensely hot, the other dark to us. He does not think it necessary, however, to regard the companion as absolutely dark, but only relatively so to us, but it may be still glowing and emitting light, provided its brightness is less than $\frac{1}{80}$ of that of *Algol* itself. Professor Vogel calls attention in this connection to what we know of *Sirius* and his dark companion.

The Greenwich Observations give a similar difference of rate of motion at the two elongations, namely, 46 miles; Vogel's difference is 53 miles; but the motions do not so nearly balance each other, leaving a large motion of approach of the whole system.

It need scarcely be said that Professor Vogel's final results on *Algol* and the other stars photographed at Potsdam will be awaited with much interest.   W. H.

Photographic Photometry.

The readiest and most effective means of determining the magnitudes of stars from an examination of the discs impressed on a sensitised film is a problem that has received much attention during the past year, and contributions to the literature of the subject have recently been made from the three observatories of Harvard, Stockholm, and Potsdam. It will, perhaps, be generally felt that in a problem of such importance and such interest the last word has not yet been said.

Professor Pickering's method is described, and his results are given in vol. xviii. of the *Annals* of the Harvard Observatory. The vigour and enterprise which characterise the direction of that institution have enabled the director to give no less than three catalogues of magnitudes, embracing, on the whole, some 2500 stars. The first of these catalogues gives the photo-

graphic magnitudes of all the stars brighter than the fifteenth magnitude, within one degree of the pole. The method employed in the determination of these magnitudes was to compare the trail of a star, obtained under various conditions, with the trails of those stars whose magnitude was sought.

The second catalogue contains the magnitudes of many of the stars in the *Pleiades* group. Here the method of trails was inappropriate, and the magnitude was derived by comparing the discs of two stars in the *Hyades*, as given by exposures of known but various lengths, with those impressed on the *Pleiades* plates. An additional check on the accuracy was supplied by means of a catalogue of 14 standard stars, whose magnitudes had been determined by the wedge photometer.

The third catalogue is deduced by the method of trails. It gives the photographic brilliancy of 1131 stars generally brighter than the eighth magnitude, situated near the equator. The object of this investigation is to furnish a catalogue free from systematic error with which stars in all parts of the sky can at any time be conveniently compared. A comparison between the photographic and photometric magnitudes of 500 of these stars leads to the conclusion that for stars brighter than the fifth magnitude the numerical photographic magnitudes are in excess by one unit. The photometric and the photographic scales continually approach each other as the stars grow fainter, till at 8·5 they are coincident. Here the scales cross and the photometric magnitudes are numerically greater than the photographic. Professor Pickering has given both the photographic magnitude and the same quantity reduced to the photometric scale.

The contribution from the Potsdam Observatory has been translated and published under the auspices of the International Committee for Promoting the Photographic Chart of the Heavens. It is confined to the discussion of the magnitudes of stars in the *Pleiades* as impressed on plates taken with a chemically corrected object-glass by Dr. Scheiner, and with the reflecting telescope of the Herény Observatory, supplemented by some photographs of the artificial stars in a Zöllner photometer.

Dr. Scheiner has not been fortunate in his negatives. The images on the *Pleiades* plates are in neither instance circular, probably from want of accurate driving, but Dr. Scheiner believes that by measuring both the major and minor axes of the resulting ellipses, and using the square root of the product in his researches, he has effectually removed any source of error from this cause. The principal results of the inquiry are twofold: first that the increase of the diameter of the disc varies as the square root of the time of exposure, and secondly that a simple linear relation exists between the observed diameter and the magnitude, or

$$m = a - bD,$$

where a and b are constants to be determined from each plate if accuracy be required; but, as a rule, Dr. Scheiner believes

that a simple inspection of the stellar discs, aided, it may be, by some mechanical contrivance to assist the memory, will be sufficient to give the magnitude with a fair amount of approximation.

The third contribution to this subject is from Dr. Charlier, of Stockholm, whose aim is to determine the form of the function which expresses the connection between the photographic brilliancy of a star and its photographed image in such a manner as to ensure a coincidence as far as possible between the photographic and photometric magnitudes. The research, which is conducted with great care, is founded upon two series of plates, made with a chemically achromatised object-glass of 81 mm. aperture and 100 cm. focal length. In one series of photographs the *Pleiades* group is taken on four plates, with times of exposure varying from 13 to 180 minutes, and thus stars of great difference in brilliancy have been photographed in the same time on the same plate; in the second series *Polaris* is photographed on the same plate with different exposures, and therefore the light is constant and the time variable.

The formula employed in the reduction of the observations differs from that adopted by Dr. Scheiner and more nearly resembles that suggested by Professor Pritchard in 1886, inasmuch as both agree that a simple linear expression is not admissible, and prefer a logarithmic function. Dr. Charlier expresses the relation between the magnitude m and the diameter D by the equation

$$m = a - b \log D,$$

and remarks that where only one instrument and one kind of plate are concerned b may be assumed constant, and for the Stockholm apparatus he finds from the *Pleiades* series

$$b = 6 \cdot 75.$$

If the sensitiveness of the plate be supposed to remain constant and the observations are made only at those times when the atmospheric conditions are at their best, a may be regarded as a function of the time of exposure, and Dr. Charlier proposes the following form:

$$a = 17 \cdot 2 + 1 \cdot 69 \log t,$$

t being expressed in minutes. The value of a, however, given by this formula is not that used in the subsequent reductions, but a value has been computed for each plate by inserting Lindemann's photometric magnitudes m of the 52 Besselian stars in the formula

$$a = m + 6 \cdot 75 \log D.$$

The *Polaris* series of negatives is well adapted for the discussion of the variation of the diameter with the time of exposure, and Dr. Charlier thinks the evidence warrants the conclusion that

this increase varies as the fourth root of the time. This result, which disagrees with that mentioned above as found by Dr. Scheiner, is in accord with that given by Prof. Pritchard.

Adopting, however, this law of increase, Dr. Charlier finds that his observations of measured diameter can be reduced consistently to photometric magnitude by the formula already given, or by

$$m = 17 \cdot 2 - 6 \cdot 75 \log \cdot \frac{D}{\sqrt[4]{t}}.$$

We are thus in possession of the photographic magnitudes of the stars in the *Pleiades* determined by three different methods. In one of these series, that of Dr. Scheiner, the inquiry is limited to the brighter stars of the group only, and it is owing to this limitation that he has been able to use so simple a formula as that quoted. Dr. Charlier has shown that when stars greatly differing in brilliancy are compared the employment of such a formula is misleading. The other two series, however, viz. those of Harvard and Stockholm, which contain the fainter stars of the group, are available both for mutual comparison and also for comparison with the magnitudes assigned to the same stars by M. Wolf.

The comparison of the scales of Charlier and Pickering is not altogether satisfactory, and suggests the possibility of systematic error in one or other of the two series. For stars of the tenth magnitude the scales coincide, but to fainter stars Prof. Pickering ascribes a larger, and to brighter stars a smaller, numerical magnitude than does Dr. Charlier. This peculiarity, however, is not noticeable in the comparison of the Harvard fourteen standard stars, referred to above, and from this fact Dr. Charlier concludes that the cause of the systematic error will not be found in the Stockholm observations. From a comparison of either series with the magnitudes assigned by M. Wolf, it would seem that there is no reason to conclude that stars much fainter than 15·5 magnitude have yet been photographed.   W. E. P.

The Photographic Chart of the Heavens.

The Permanent Committee, appointed by the Astrophotographic Congress of 1887, held their first meeting at the Paris Observatory in September of the past year, under the presidency of Admiral Mouchez, and the proceedings have been published, like the *Bulletin*, through the liberality of the Académie des Sciences.

The meeting was attended by eighteen members of the committee:—MM. Anguiano, Baillaud, Bakhuyzen, Beuf, Christie, Cruls, Dunér, Paul Henry, Prosper Henry, Janssen, Kapteyn,

Loewy, Mouchez, Pujazon, Rayet, Tacchini, Trépied, and Weiss; also by twenty-one other astronomers, specially invited.

The *séances* were opened on September 16 with an address from Admiral Mouchez, after which MM. Christie and Dunér were appointed vice-presidents, and MM. Bakhuyzen and Trépied secretaries.

A provisional programme of questions for discussion was laid before the committee, and the important subjects of the distribution of the work among the different observatories and the selection of test-objects were submitted to a special committee consisting of MM. Beuf, Christie, Cruls, and Loewy.

The results of the seven *séances* which were held are contained in a series of twenty-eight resolutions, of which we may mention the more important.

The zones assigned to the several participating observatories are as follows :—

North.

	Latitude.	Zone.
Helsingfors	+60 9	+90 − 70
Potsdam	+52 22	70 − 58
Oxford	+51 45	58 − 48
Greenwich	+51 28	48 − 40
Paris	+48 50	40 − 32
Vienna	+48 13	32 − 24
Bordeaux	+44 50	24 − 18
Toulouse	+43 37	18 − 12
Catane	+37 30	12 − 6
Algiers	+36 48	6 − 0
San Fernando	+36 27	0 − 6
Chapultepec	+19 26	− 6 − 12
Tacubaya	+19 24	12 − 18

South.

Rio de Janeiro	−22 54	−18 − 26
Santiago	−33 26	26 − 34
Sydney	−33 51	34 − 42
Cape of Good Hope	−33 56	42 − 52
La Plata	−34 55	52 − 70
Melbourne	−37 50	70 − 90

Twelve test-objects were selected, all of which are situated near the equator, at intervals of about two hours of right ascension. In addition to these the *Pleiades, Præsepe*, and a group in *Cygnus* were selected for the use of the more northern observatories.

It was decided that the field of the telescope available for measurement should be 2° square; that the photographic plates employed (which are to be of plate glass) shall be 160 mm. (6¼ inches) square and the réseaux 130 mm. (5⅛ inches) square, with the lines 5 mm. apart.

Much consideration was given to the important question of fixing the time of exposure for the second series of plates, so as to ensure that they shall. contain stars to magnitude 11·0, and it was eventually resolved to determine the time necessary to photograph a star of magnitude 9·0 of Argelander's scale, and then multiplying that by 6·25 will give the exposure for magnitude 11·0. Another important resolution was passed respecting the catalogue plates to the 11th magnitude, viz. that there shall be two exposures on each plate : the first to give stars to magnitude 11·0, and the second with one quarter the duration of the first, and with a displacement of 0·2 to 0·3 mm. as a check against defects and spurious stars.

Two numbers (3 and 4) of the *Bulletin* of the Permanent Committee have been published during the past year, which contain several papers of interest and importance. Professor Bakhuyzen contributes one on the measurement of the plates by the method of rectangular co-ordinates, in which he gives the results of its application from the measurement and reduction of a plate taken by the Brothers Henry. The places obtained compare very favourably with meridian places. Professor Vogel, who has generously offered to construct and verify all the réseaux required, contributes one or two papers on the subject of the réseaux and the measurement of the plates. Professor Kapteyn has suggested in the fourth number the expediency of taking the catalogue plates with three exposures at intervals of six months, and with a slight displacement on each occasion. By this means he considers data could be secured for determining the stars' proper motions and parallaxes. A further important and valuable paper by Dr. Scheiner in the same number, on the application of photography to the determination of stellar magnitudes, has been noticed on another page.

The past year has seen the generous gift of $50,000 to the Harvard College Observatory from Miss Bruce, of New York, for the construction of a photographic telescope of 24 inches aperture and 11 feet focal length. With this instrument Professor Pickering has proposed to make a photographic chart of the heavens somewhat different in character from that decided on by the Paris Congress. This telescope will differ from other large instruments in the construction of its object glass, which will be a compound lens of the form known as a photographic doublet. A portion of the sky covering 25 square degrees will be photographed on each plate on a scale of one minute to a millimetre, and it is contemplated that stars of the 16th magnitude, and even fainter, will be photographed by it.

We cannot doubt that under the able and energetic direction

of Professor Pickering this telescope will produce results of the highest interest and value to astronomy.

Spectroscopic Astronomy in 1889.

The Sun.—Mr. Lockyer has presented a second report to the Solar Physics Committee on the observations of Sun-spot spectra made at South Kensington. The previous report covered the period from November, 1879, to August, 1885, and included 700 observations of spot-spectra. The present report carries on the record to February, 1888, but as the spot activity of the Sun was rapidly declining during this period, only 150 observations could be secured. These, however, quite confirm the conclusion arrived at by Mr. Lockyer in 1886 that "as we pass from mini-mum to maximum the lines of the chemical elements gradually disappear from among those most widened, their places being taken by lines of which we have at present no terrestrial repre-sentatives," and especially is this so for the region between F and *b*.

A paper read before this Society by the Revs. S. J. Perry and A. L. Cortie, in which the region C to D, as seen in the spectrum of a spot at the time of maximum, was compared with the same region in another spot at the time of minimum, fully confirms Mr. Lockyer's inference with regard to the lines of known metals, and especially of iron; but no special difference was noted in the behaviour of the unidentified lines in the two spots.

A fresh determination of the rotation period of the Sun by the spectroscopic method has been effected by Mr. Henry Crew, 26·23 days being obtained as the value of the sidereal rotation. Mr. Crew calls attention to the fact that this is considerably longer than the period derived from observation of the faculæ or spots, and that this again is longer than the period which some observers have inferred from the variation of the magnetic elements. He therefore makes the suggestion that these different values may be derived from different solar levels, and that the angular velocity of the lower levels may be greater than that of the higher.

The Telluric Spectrum.—M. Janssen has confirmed the con-clusions which he drew from the results of his expedition to Les Grands Mulets in 1888, that the oxygen lines of the telluric spectrum are wholly due to the influence of our own atmosphere, and in no degree to that of the Sun, by a series of observations of the spectrum of an electric light placed on the Eiffel Tower as viewed from the Observatory of Meudon.

The Aurora.—Dr. Huggins has communicated to the Royal Society an important paper on the wave-length of the principal line in the spectrum of the Aurora, showing cause for regarding

its value as $\lambda = 5571$. Mr. Lockyer, who had identified the
line with the fluting of manganese at $\lambda\ 5580$, has replied to the
effect that his inference had been justified by such facts as had
been accessible to him at the time, that the two lines are un-
doubtedly very near to each other, and that a direct comparison
of the two spectra at the earliest opportunity is imperatively
called for.

Saturn's Ring.—The question of the presence of bright lines
in various planetary and stellar spectra has come into great pro-
minence during the past year, and there is yet great difference of
opinion between different observers. With regard to the spectrum
of *Saturn's* Ring, Mr. Lockyer considered that he had obtained
some indications in a photograph of the existence of such bright
lines, but the evidence was not sufficiently strong for him to
announce their presence as an undoubted fact. Dr. Huggins, on
the other hand, could obtain from a photograph which he took
nothing but an ordinary solar spectrum, and direct eye observa-
tion with a spectroscope attached to the great equatoreal of the
Lick Observatory led Mr. Keeler to a similar conclusion.

Uranus.—Mr. Albert Taylor has examined the spectrum of
this planet in great detail by means of a spectroscope mounted
upon Mr. Common's five-foot reflector, and it was his decided
impression that bright flutings as well as dark absorption bands
formed a marked feature of the spectrum. His opinion has not,
however, received any support either from the photographs Dr.
Huggins has taken or from the eye-observations made by Mr.
Keeler at the Lick Observatory.

Bright Lines in Stellar Spectra.—Mr. Espin has continued
his search for stars with remarkable spectra and has been
rewarded by further discoveries of bright lines in the spectra of
a number of variable stars when near their maxima : *R Leonis,
R Hydræ, χ Cygni, R Andromedæ,* and *S Cassiopeiæ.* The fore-
going stars are all of Secchi's third type, but the observers at
the Lick Observatory have suspected the presence of similar
lines in the spectra of two stars of the fourth type, *U* and *V Cygni,*
and when these stars were far removed from their maximum.
It is therefore particularly desirable that these stars should be
carefully watched as they increase in brightness. Mr. Keeler
also finds that he is able to break up the apparently continuous
spectra of stars of the type of the Wolf-Rayet stars in *Cygnus*
into "an extremely complicated range of absorption bands and
faint bright lines." These observations are of especial interest
at the present time from the remarkable accord which they
present with the views Mr. Lockyer has put forward in the
development of his meteoritic theory.

A remarkable form of spectrum has been discovered by Pro-
fessor Pickering in that of the star *Pleione,* for the F line con-
sists in this case of a narrow bright line superposed on a broader
dark line, the other hydrogen lines showing some indications of
a similar character.

Spectroscopic Surveys.—The Third Report of the Henry Draper Memorial announces the practical completion of two branches of the work undertaken with the funds provided by Mrs. Henry Draper, the photographic survey of the spectra of all stars north of 25° S. Dec. having been effected on a twofold scale, the one survey including all stars brighter than the 7th magnitude, the other including stars two magnitudes fainter. The Bache 8-inch doublet employed in this work has been transferred to a station near Chosica in Peru, and similar surveys for the stars down to the South Pole have been commenced. Already nine stars of the Wolf-Rayet type have been discovered, whilst θ *Muscœ*, like φ *Persei* and γ *Cassiopeiœ*, has been found to show the F line bright.

A spectroscopic survey of the southern heavens by direct observation has been undertaken at the Melbourne Observatory. Two lists of spectra observed with a Maclean spectroscope on the 8-inch equatoreal in the course of a preliminary reconnaissance have already been published, but a more powerful spectroscope will be used in connection with the 4-foot reflector later on.

Motion of Stars in the Line of Sight.—Besides the routine work carried on at the Royal Observatory, Greenwich, and the observations made by Mr. Seabroke at Rugby, some valuable results in this field of spectroscopy have been secured by Professor Vogel, which are, however, referred to on another page. Some remarkable illustrations of the principle of observation have been discovered by Professor Pickering, for he found the K line in the spectrum of ζ *Ursœ Majoris* to be double at intervals of fifty-two days. The present explanation of this strange variation is that the star is really a double star, of which the components are practically equal in size, and too close to have been separated hitherto by the means at our command. In their revolution round their common centre of gravity, the two stars are sometimes both moving perpendicularly to the line of sight—when the lines of the combined spectrum are seen in their true positions—and sometimes one is approaching the Earth whilst the other recedes, giving rise to a displacement of the lines of the two spectra in contrary directions, and hence to an apparent doubling of the lines. β *Aurigœ* and *b Ophiuchi* have spectra exhibiting a similar and periodic change.

The Great Nebula in Orion.—Dr. and Mrs. Huggins have communicated to the Royal Society a very valuable paper on the visible and photographic spectrum of this nebula. Besides determining the places of thirty-six lines, the authors have arrived at the following three principal conclusions: (1) It does not appear that magnesium is represented in the nebular spectrum. (2) The two photographs taken in 1888 gave an entirely different spectrum from one taken over a different but still adjacent part of the nebula about a year later. (3) Two of the trapezium stars seem to give the same groups of bright lines as

the surrounding nebula, and are therefore "physically bound up with it, and are very probably condensed out of the gaseous matter of the nebula."

Mr. Albert Taylor has also observed the visible portion of the spectrum, and added several new lines to those previously recognised.

Limit of Solar and Stellar Light in the Ultra-Violet Part of the Spectrum.—Dr. Huggins has found, as is stated more at length in the report of his Observatory, that the photographic spectra of *Vega* and of the Sun suffer an abrupt weakening at about λ 3000, and apparent total extinction at λ 2970. The observations of Cornu, Hartley, and quite recently of Liveing and Dewar, appear to show that the definite absorption to which the very rapid extinction of the solar spectrum is due has its seat in the Earth's atmosphere, and not in that of the Sun, and is caused by one of its gaseous constituents, probably oxygen, and not by aqueous vapour. Dr. Huggins thus confirms this conclusion by showing that the limit of the spectrum is practically the same for *Vega* as for the Sun.   **E. W. M.**

Professor Spoerer's Researches on Sun-spots.

Professor Spoerer, who has devoted much attention not only to the current state of the solar activity, but also to the early records of Sun-spots, published early in 1889 two important papers on the results of his researches in the latter field. The two papers are entitled respectively " Ueber die Periodicität der Sonnenflecken seit dem Jahre 1618," communicated to the Royal Leopold-Caroline Academy, and "Sur les différences que présentent l'hémisphère nord et l'hémisphère sud du Soleil," appearing in the number of the *Bulletin Astronomique* for February 1889. The conclusions arrived at in these two papers may be summarised under the three following heads :—

First. These earlier observations afford us many examples of the operation of the "law of zones ; " that is to say, a little before a minimum spots are only seen in low latitudes, at about the time of minimum spots near the Equator cease to appear, whilst a fresh series of spots break out at a great distance from it, and from thenceforward to the next minimum the mean heliographic latitude of the spots tends to decline continuously, until at length spots are again seen only in the vicinity of the Equator. This law held good, Professor Spoerer shows, for the minima of 1619, 1755, 1775, 1784, 1833, and 1844, and to some extent for that of 1645.

Second. Though in general a predominance for a time of spots in one hemisphere is sooner or later balanced by a corresponding predominance in the other, this is not always the case, and Professor Spoerer calls attention to three periods in which the southern hemisphere was decidedly the more prolific. The

first was from 1621 to 1625, there being no northern spots in 1621 and 1622, and but few in the three following years. Another is the present period, for from 1883 to the present time the southern spots have been nearly twice as numerous as the northern. But the third was the most remarkable, for from 1672 to 1704 we have no record of any northern spots at all; and Cassini and Maraldi expressly declared on the appearance of a northern spot in 1705 that they did not recollect ever to have observed a spot in that hemisphere before. Northern spots continued to be infrequent until 1714.

Third. For a period of about seventy years, ending in 1716, there seems to have been a very remarkable interruption of the ordinary course of the spot cycle. In several years no spots appear to have been seen at all, and in 1705 it was recorded as a most remarkable event that two spots were seen on the Sun at the same time, for a similar circumstance had scarcely ever been seen during the sixty years previous. So far as the observations go, the "law of zones" also seems to have been in abeyance, for no regular drift was apparent, the mean latitude being low—about 8° or 9°—during the entire time.

Professor Spoerer is still continuing his researches into ancient Sun-spot records, and hopes to be able to examine the manuscripts of Plantade (1705–1726) and of Flaugergues (1794–1830).   E. W. M.

Jupiter.

The four following memoirs on the physical appearance of *Jupiter* have recently appeared:—

(1) "Études sur l'Aspect Physique de la Planète Jupiter," par Dr. F. Terby (vol. xlix. of the *Mémoires Couronnées* of the Royal Academy of Sciences of Belgium). This memoir, which is illustrated by 100 sketches of the planet made by means of a telescope of $3\frac{1}{2}$ inches aperture, contains the author's observations from 1882 to 1885, and is in continuation of an earlier paper appearing in vol. xlvii. of the same publication. The special feature of the memoir is the attempt to identify the details of the planet's surface in successive rotations, a work which Dr. Terby believes he has been able to accomplish more successfully in 1887, when he had the assistance of his present refractor of 8 inches aperture.

(2) "Observations of the Planet Jupiter." By Dr. Otto Boeddicker (Royal Dublin Society, *Scien. Trans.* vol. iv. series 2, March 1889). These observations comprise 84 drawings of the planet made with the 3-foot reflector of Lord Rosse's Observatory, Parsonstown, in the years 1881 to 1886. The drawings have been reproduced without alteration or retouching by a photo-mechanical process. The special feature of the memoir is the great amount of detail shown in the drawings.

(3) "On the 'Belts and Markings of Jupiter." By N. E. Green (*Mem. R.A.S.* vol. xlix. 1889). This paper presents the conclusions which the author has deduced from the careful study of *Jupiter* during every opposition from 1859 to 1887, and from the comparison of hundreds of drawings. The paper is accompanied by 21 drawings showing an immense amount of detail and much delicate gradation of colour. The special feature of the paper is the evidence presented as to the relations of the light and dark markings, and the inferences drawn as to the physical condition of the planet.

(4) "Zenographical Fragments. No. 1. The Motions and Changes of the Markings on Jupiter in the Apparition of 1886–87." By A. Stanley Williams. This volume contains the author's observations during the apparition of 1886–87, and is illustrated by 52 diagrams. Its special feature is the determination of the rotation period of *all* the distinctive markings of the planet for which it was possible to effect it, and it contains, therefore, very full observations of the times of transit across the central meridian of a great number of dark or bright spots.

<div style="text-align:right">E. W. M.</div>

Charts of the Constellations.

Mr. Arthur Cottam has recently published a series of charts of the constellations, its purpose being to serve as a companion to the 4th edition of the late Mr. Webb's " Celestial Objects for Common Telescopes," and also to Mr. Chambers' edition of the " Bedford Catalogue," to which end the author has incorporated the whole of the stars in Lord Crawford's summary of the " Dorpat Catalogue," together with about one thousand multiple and variable stars from the " Pulkowa Catalogue " and those of Mr. Burnham.

The series consists of 36 charts, each showing one entire constellation and parts of those adjoining, projected conically, and including that part of the celestial sphere which lies between the North Pole and declination 30° S. A special feature of the work is the large scale on which the circles representing the stars are drawn, the object of which is to meet a criticism of Sir J. Herschel that in star charts generally the brighter stars are not sufficiently prominent.

Papers read before the Society from March 1889 to
February 1890.

1889.
March 8. On the satellite of *Venus* and its revolution.   Professor
C. V. Zenger.

On a graphical method for determining the orbit of a
binary star.   Professor S. Glasenapp.

Discovery of comet Brooks (*a* 1889).   W. R. Brooks.

Observations of phenomena of *Jupiter's* satellites, made
at Windsor, New South Wales, in the year 1888.
John Tebbutt.

Observations of the variable star S (10) *Sagittæ*.   J. E.
Gore.

Observations of the planet *Iris* and comparison stars
made with the meridian circle at Dunsink.   A. A.
Rambaut.

Photographic analysis of the great nebula M 42 and 43
and *h* 1180 in *Orion*.   Isaac Roberts.

Preuves de la Nutation diurne : mode d'observation
propre à la mettre en évidence en une seule soirée.
Professor F. Folie.

Observations of comet *f* 1888 (Barnard) made at Stony-
hurst College Observatory.   Rev. W. J. Crofton.

A new pair-mirror equatoreal arrangement.   Rev. A.
Freeman.

On the determination of normal places.   Lieut.-Gen.
J. F. Tennant.

On the orbit of comet I. 1888 (Sawerthal).   Lieut.-
Gen. J. F. Tennant.

Observations of comet Barnard (September 2, 1888),
and comet Barnard (October 30, 1888), made at the
Radcliffe Observatory, Oxford.   Communicated by
E. J. Stone.

Note on a red star.   E. J. Stone.

The Greenwich standard right ascensions for 1880.
A. M. W. Downing.

Spectroscopic observations of sundry stars and comets
made at the Royal Observatory, Greenwich, chiefly
in the years 1887 and 1888.   E. W. Maunder.

On the value of a scale of density on a photograph.
Captain W. de W. Abney.

Note on the law of increase in diameter of star discs on
stellar photographs with duration of exposure. H. H.
Turner.

Note on the spectrum of the great nebula in *Orion*.
E. W. Maunder.

April 12. On an error in Brünnow's formulæ for differential re-
fraction in distance and position angle. W. H.
Finlay.

Observations of comets made at the Orwell Park Ob-
servatory in the years 1888–89. J. I. Plummer.

The trapezium of *Orion*. S. W. Burnham.

Probable errors of Greenwich determinations of right
ascension at different zenith distances. A. M. W.
Downing.

On the proper motion of 85 *Pegasi*. J. E. Gore.

On the photographs of the corona at the solar eclipse
of January 1, 1889. Professor E. S. Holden.

Photographs of the nebulæ M 81, 82, and a nebulous
star in *Ursa Major*. Isaac Roberts.

A catalogue of the stars of the IV. type. Rev. T. E.
Espin.

Note on an error in Le Verrier's "Tables du Soleil."
R. T. A. Innes.

On a method of supporting a large mirror when silver-
ing. Edward Crossley.

May 10. Photographs of the nebula M 51 *Canum Venaticorum*.
Isaac Roberts.

Mean areas and heliographic latitudes of Sun-spots,
1874 to 1888, deduced from photographs taken at
Greenwich, at Dehra Dûn, India, and at Mauritius.
Communicated by the Astronomer Royal.

Parallel photographs of the spectra of the Sun, of iron,
and of iridium, from H to near D; also separate pho-
tographs of the spectrum of titanic iron ore. F.
Maclean.

Ephemeris for physical observations of the Moon.
A. Marth.

Observations of the planet *Iris* and comparison stars
made with the transit circle of the Radcliffe Observa-
tory, Oxford, during the opposition of 1888. Com-
municated by E. J. Stone.

Observations of Terby's white spot on *Saturn's* ring.
A. A. Common.

June 14. On the orbit of *Sirius*. J. E. Gore.

Note on the nebulous star in Mr. Roberts's photograph
of 81 and 82 Messier *Ursæ Majoris*. Herbert Ingall.

Photographs and drawings of the Sun. Rev. S. J.
Perry.

Comparison of the spectrum between C and D of a Sunspot observed May 27, 1884, with another of May 7, 1889. Rev. S. J. Perry and Rev. A. L. Cortie.

Observations of the spectrum of *Uranus.* A. Taylor.

Nov. 8. On the close conjunction of *Mars* and *Saturn* near *Regulus,* September 19, 1889. A. Marth.

On the eclipse of *Iapetus* by *Saturn* and its ring system, November 1–2, 1889. A. Marth.

The photographic spectrum of the nebula of *Orion.* (Extract from a letter to Mr. Knobel.) Dr. W. Huggins.

The spectra of *Uranus* and *Saturn.* Dr. W. Huggins. (Extract from a letter to Mr. Knobel.)

The nebula G. C. 2091. E. E. Barnard.

Discussion of the observations of the Sun made with the Washington transit circle during the years 1875–83, inclusive. A. M. W. Downing.

Ephemeris of the satellites of *Saturn,* 1889–90. A. Marth.

Suggestions as to a new general catalogue of stars. G. F. Chambers.

Ephemeris of the satellite of *Neptune,* 1889–90. A. Marth.

Catalogue of 918 radiant points of shooting stars observed at Bristol. W. F. Denning.

Catalogue of bright meteors observed at Bristol during the years 1877 to 1889 inclusive. W. F. Denning.

Preliminary spectroscopic survey of southern stars made at the Melbourne Observatory with a Maclean direct-vision spectroscope on the 8-inch equatoreal. Communicated by R. L. J. Ellery.

Observations of comets *d* 1889 (Brooks) and *e* 1889 (Davidson) made at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.

On some of the features of the arrangement of stars in space. Professor E. S. Holden.

Conjunction of *Mars* and *Saturn,* September 20, 1889. Major S. H. Maxwell.

Observations of comet *e* 1889 (Davidson) made at the Melbourne Observatory with the South equatoreal and dark field micrometer. Communicated by R. L. J. Ellery.

On the proper motion of the double star South 503. J. E. Gore.

Observations of comet *e* 1889 (Davidson) made at the Sydney Observatory with the 11½-inch equatoreal and filar micrometer. Communicated by H. C. Russell.

Note to accompany a drawing of the Milky Way. Dr. O. Boeddicker.

The colours of stars. F. W. Levander.

Results of double star measures at Windsor, New South

Wales, during the years 1886, 1887, and 1888. John
Tebbutt.

The orbit of comet III., 1888. Lieut.-Gen. J. F.
Tennant.

Occultation of *Jupiter* by the Moon, August 7, 1889,
observed at Forest Lodge, Maresfield. Captain W.
Noble.

Note on solar spots in high south latitudes. Rev. S. J.
Perry.

Discussion of Greenwich north polar distances of *Polaris*
and other stars, with reference to corrections for tem-
perature and humidity. W. G. Thackeray.

Note on the bright line spectra of R *Andromedæ* and
R *Cygni*, and on the suspected bright lines in R *Cassio-
peiæ*, and on the spectrum of W. *Cygni*. Rev. T. E.
Espin.

Ephemerides of the satellites of *Saturn*, 1889–90 (con-
clusion). A. Marth.

Note on the determination of stellar parallax by the aid
of photography. Professor C. Pritchard. ·

Occultation of the planet *Jupiter* and its satellites by
the Moon, August 7, 1889, observed at the Radcliffe
Observatory, Oxford. E. J. Stone.

Observations of *Mars* and *Saturn* at their conjunction,
September 19, 1889, made at the Royal Observatory,
Greenwich. E. W. Maunder.

Brooks's Comet. J. I. Plummer.

Dec. 13. Areas of faculæ and Sun-spots, compared with diurnal
ranges of magnetic declination, horizontal force, and
vertical force, as observed at the Royal Observatory,
Greenwich, in the years 1873 to 1888. Communi-
cated by the Astronomer Royal.

Mean daily area of Sun-spots for each degree of solar
latitude for each year from 1874 to 1888 as measured
on photographs taken at the Royal Observatory,
Greenwich. Communicated by the Astronomer
Royal.

Observations of occultations of *Jupiter* by the Moon,
August 7, 1889, made at the Royal Observatory,
Greenwich. Communicated by the Astronomer
Royal.

The late occultation of *Jupiter*. Rev. S. J. Johnson.

On the orbit of Struve 228. J. E. Gore.

Spectra of southern stars observed at the Melbourne
Observatory with the Maclean direct-vision spectro-
scope, attached to the South equatoreal. No. II.
Communicated by R. L. J. Ellery.

Spectroscopic observations of the motions of stars in
the line of sight, made at the Temple Observatory,
Rugby. G. M. Seabroke.

Ephemeris for physical observations of the Moon,
January 1 to July 1, 1890.   A. Marth.
Note on the spectrum of the Sun-spot of June, 1889.
Rev. A. L. Cortie.
A method of recording the transits of stars by photo-
graphy.   W. E. Wilson.

1890
Jan. 10. The photographic apparatus of the great equatoreal of
the Lick Observatory.   Professor E. S. Holden.
Observations of the eclipse of *Iapetus* in the shadows of
the globe, crape ring, and bright ring of *Saturn*,
November 1, 1889.   E. E. Barnard.
Observations of occultations of stars by the Moon, and
phenomena of *Jupiter's* satellites made at the Royal
Observatory, Greenwich, in the year 1889.   Com-
municated by the Astronomer Royal.
Ephemeris for physical observations of *Mars*, 1890.
A. Marth.
Ephemeris of the satellites of *Uranus*, 1890. A. Marth.
Ephemeris of the satellites of *Mars*, 1890.   A. Marth.
The structure of the sidereal universe.   T. W. Back-
house.
Spectroscopic results for the motions of stars in the line
of sight obtained at the Royal Observatory, Green-
wich, in the year 1889.   No. XIII.   Communicated
by the Astronomer Royal.

*List of Public Institutions and of Persons who have contributed to
the Library, &c., since the last Anniversary.*

Her Majesty's Government.
Her Majesty's Government in Australia.
Her Majesty's Government in India.
The Lords Commissioners of the Admiralty.
The French Government.
British Association for the Advancement of Science.
British Horological Institute.
Camera Club.
City of London College.
Geological Society of London.
Institute of Civil Engineers.·
Meteorological Office.
Photographic Society of Great Britain.
Physical Society of London.
Royal Geographical Society.
Royal Institution of Great Britain.
Royal Meteorological Society.
Royal Observatory, Greenwich.
Royal Society of London.
Royal United Service Institution.
Society of Arts.
University College, London.
Zoological Society of London.
Belfast Natural History and Philosophical Society.
Birmingham Philosophical Society.
Bristol Museum and Library.
Cambridge Philosophical Society.
Dublin, Royal Irish Academy.
Dublin, Royal Society.
Dulwich College Science Society.
Dunsink Observatory.
Edinburgh, Royal Observatory.
Kew Observatory.
Leeds Philosophical and Literary Society.
Liverpool Astronomical Society.
Manchester Literary and Philosophical Society.
Middlesex Natural History and Science Society.

Oxford, Clarendon Press.
Oxford, Radcliffe Trustees.
Oxford University Observatory.
Rugby School Natural History Society.
Stonyhurst College Observatory.
Truro, Royal Institution of Cornwall.
Amsterdam, Royal Academy of Sciences.
Batavia Magnetical and Meteorological Observatory.
Berlin, German Transit of *Venus* Commission.
Berlin, Physical Society.
Berlin, Royal Academy of Sciences.
Berlin, Royal Observatory.
Berlin, Royal Prussian Geodetic Institute.
Berne University.
Bologna, Royal Academy of Sciences.
Bombay Branch of the Royal Asiatic Society.
Bombay, Government Observatory.
Bonn, Royal Observatory.
Bordeaux, Society of Physical and Natural Sciences.
Boston, American Academy of Arts and Sciences.
Brisbane, Queensland Branch of the Royal Geographical
     Society of Australasia.
Brussels, Royal Academy of Sciences.
Brussels, Royal Observatory.
Buda-Pesth, Hungarian Academy of Sciences.
Buenos Ayres, Argentine Meteorological Office.
Calcutta, Asiatic Society of Bengal.
Canada, Geological and Natural History Survey.
Cape of Good Hope, Royal Observatory.
Carlsruhe Observatory.
Coimbra Observatory.
Copenhagen, Royal Academy of Sciences.
Cordoba, Argentine National Observatory.
Cracow, Academy of Sciences.
Delft, Polytechnic School.
Dijon, Academy of Sciences, Arts and Letters.
Geneva, Society of Physics and Natural History.
Göttingen, Royal Society of Sciences.
Haarlem, Teyler Museum.
Halle, Leopold-Caroline Academy of Naturalists.
Hamburg, Mathematical Society.
Harvard College Astronomical Observatory.
Haverford College Observatory.
Helsingfors, Geographical Society of Finland.
Helsingfors Observatory.
Helsingfors, Society of Sciences of Finland.
Hong Kong Observatory.
International Geodetic Association.
Italian Meteorological Society.
Japan, Seismological Society.

Kalocsa Observatory.
Kasan, Observatory of the Imperial University.
Leghorn, Technical and Nautical Institute.
Leipzig, Astronomical Society.
Leipzig, Royal Saxon Society of Sciences.
Lick Observatory of the University of California.
Lund Observatory.
Madrid Observatory.
Madrid, Royal Academy of Sciences.
Marseilles, Flammarion Scientific Society.
Mauritius, Royal Alfred Observatory.
Melbourne Observatory.
Milan, Royal Observatory.
Moncalieri Observatory.
Montreal, Royal Society of Canada.
Montsouris Observatory.
Moscow, Imperial Society of Naturalists.
Moscow Observatory.
Munich, Royal Bavarian Academy of Sciences.
Munich, Royal Observatory.
Naples, Royal Academy of Sciences.
Natal Observatory.
Nebraska University.
Neuchatel, Society of Natural Sciences.
Ottawa, Canadian Meteorological Office.
Palermo Royal Observatory.
Paris, Academy of Sciences.
Paris, Astronomical Society of France.
Paris, Bureau of Longitude.
Paris, General Depôt of Marine.
Paris, International Committee of Weights and Measures.
Paris, Mathematical Society of France.
Paris Observatory.
Paris, Philomathic Society of France.
Paris, Polytechnic School.
Philadelphia, American Philosophical Society.
Philadelphia, Franklin Institute.
Potsdam Astrophysical Observatory.
Prague, Imperial Observatory.
Pulkowa Observatory.
Rio de Janeiro Observatory.
Rome, Central Meteorological Office.
Rome, Italian Spectroscopic Society.
Rome, Pontifical Academy *dei Lincei*.
Rome, Royal Academy *dei Lincei*.
St. Petersburg, Imperial Academy of Sciences.
San Fernando Observatory.
San Francisco, Astronomical Society of the Pacific.
San Francisco, University of California.
Stockholm Observatory.

Stockholm, Royal Swedish Academy of Sciences.
Sydney, Government Observatory.
Sydney, Royal Society of New South Wales.
Tacubaya Observatory, Mexico.
Taschkent Observatory.
Tasmania, Royal Society.
Toronto, Canadian Institute.
Toulouse, Academy of Sciences.
Turin, Observatory of the Royal University.
Turin, Royal Academy of Sciences.
Vienna, Austrian Geodetic Commission.
Vienna, Imperial Academy of Sciences.
Vienna, Imperial Observatory.
Washington, National Academy of Sciences.
Washington, Office of the American Ephemeris.
Washington, Smithsonian Institution.
Washington, United States Coast and Geodetic Survey
Washington, United States Naval Observatory.
Yale College Observatory.
Zurich, Central Meteorological Institute.
Editors of the "American Journal of Mathematics."
Editors of the "American Journal of Science."
Editor of the "Astronomische Nachrichten."
Editor of the "Athenæum."
Editors of the "Bulletin des Sciences Mathématiques."
Editor of "Engineering."
Editor of the "English Mechanic."
Editor of "Himmel und Erde."
Editor of "Le Galilée."
Editor of the "Journal du Ciel."
Editor of "Die Naturwissenschaftliche Rundschau."
Editor of "Die Naturwissenschaftliche Wochenschrift."
Editors of the "Observatory."
Editor of the "Sidereal Messenger."
Editor of "Sirius."

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H. C. Russell, Esq.
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Dr. R. Schorr.
Dr. R. Schram.
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Prof. G. Spoerer.
Rev. J. N. Strassmaier.
Prof. O. Struve.
Prof. P. Tacchini.
John Tebbutt, Esq.
Señor M. Tejera.
Dr. F. Terby.
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Lieut.-Col. J. Waterhouse.
F. R. Wegg-Prosser, Esq.
Mrs. W. H. Wells.
Prof. G. D. E. Weyer.
A. Stanley Williams, Esq.
Prof. W. C. Winlock.
Dr. R. Wolf.
Prof. C. A. Young.
Prof. C. V. Zenger.

The meeting then proceeded to the election of the Officers
and Council for the ensuing year, when the following Fellows
were elected :—

President.

Lieut.-Gen. J. F. Tennant, C.I.E., R.E., F.R.S.

Vice-Presidents.

Capt. W. de W. Abney, C.B., R.E., D.C.L , F.R.S.
Arthur Cayley, Esq., M.A., Sc.D., LL.D., D.C.L., F.R.S.,
    Sadlerian Professor of Pure Mathematics, Cambridge.
W. H. M. Christie, Esq., M.A., F.R.S., Astronomer Royal.
Lieut.-Col. G. L. Tupman, R.M.A.

Treasurer.

A. A. Common, Esq., F.R.S.

Secretaries.

A. M. W. Downing, Esq., M.A.
E. B. Knobel, Esq.

Foreign Secretary.

William Huggins, Esq., LL.D., D.C.L., F.R.S.

Council.

J. C. Adams, Esq., M.A., Sc.D., LL.D., D.C.L., F.R.S.,
    Lowndean Professor of Astronomy, Cambridge.
Sir R. S. Ball, LL.D., F.R.S., Andrews Professor of Astro-
    nomy in the University of Dublin, and Royal Astronomer
    of Ireland.
Hon. Sir James Cockle, M.A., F.R.S.
Edwin Dunkin, Esq., F.R.S.
J. W. L. Glaisher, Esq., M.A., Sc.D., F.R.S.
George Knott, Esq., B.A., LL.B.
Capt. William Noble.
W. E. Plummer, Esq., M.A.
Isaac Roberts, Esq.
E. J. Spitta, Esq.
E. J. Stone, Esq., M.A., F.R.S., Radcliffe Observer.
H. H. Turner, Esq., M.A., B.Sc.

Lieut.-General J. F. TENNANT, C.I.E., R.E., F.R.S., President,
in the Chair.

The Rev. S. Runsie Craig, B.A., LL.B., F.S.S., the Rectory,
Moville, Londonderry, Ireland; and
James Edward Keeler, B.A., Lick Observatory, San José,
California, U.S.A.,

were balloted for and duly elected Fellows of the Society.

The following candidates were proposed for election, the names
of the proposers from personal knowledge being appended :—

John William Aldridge, 14 Mansford Street, Hackney
Road, London, N.E. (proposed by Rev. E. Ledger) ;
Thomas William Brownell, 26 Lincroft Street, Moss Side,
Manchester (proposed by Rev. W. H. K. Soames) ;
George Cumes, F.R.G.S., Principal of Huntingdon House
School, Teddington (proposed by G. M. Whipple) ;
George Henderson, M.R.A.S., F.S.A.Scot., F.R.S.North.
Antiq., Ovenden, Sundridge (proposed by J. C. Roger) ;
Frank Robbins, Clerk, 154 Oakley Street, Chelsea, S.W.
(proposed by R. T. A. Innes).

Report of the Eclipse Committee of the Royal Astronomical Society,
1890 *March* 14. Drawn up by H. H. Turner, Secretary to
the Committee.

No. II.

A. *General Account of the Expeditions of* 1889 *December* 22.

In the first Report, printed in the *Monthly Notices*, vol. l.,
No. 1, the arrangements for the two expeditions to be sent out
by the Society were detailed, and a programme of operations was
drawn up for the observers.

In continuation of that Report I have now to give an
account of the conduct of the expeditions, and a preliminary
statement of the results, reserving for a future Report the
complete discussion of the photographs.

No material alteration was made in the programme adopted
in the last Report. Mr. Taylor left Liverpool for Loanda by the
Royal mail steamer "Bonny" on 1889 October 9, and arrived
at Loanda on November 16. On November 19 he wrote to
Mr. Common describing the voyage. A melancholy incident of
that voyage was his interview with Commander Pullen, who
was doing longitude work at Bonny, and who died a few days
afterwards from fever. On December 23 a telegram was received
from Mr. Taylor containing the single word "Zero," which,
according to a prearranged code, signified that no results what-
ever had been obtained. It was, in fact, cloudy for the whole
of totality. This telegram was communicated verbally to the
Society on 1890 January 10. Mr. Taylor's detailed report is
given below.

Father Perry, who took with him Mr. Rooney as an assistant,
left Southampton on 1889 November 14, by the R.M.S. "Tagus."
A letter to me, dated Barbados, 1889 November 28, was read to
the Society on 1890 January 10, as follows :—

"H.M.SS. 'Comus' and 'Forward' were both at anchor in
the roadstead on arrival of mail, and the instruments were at once
transferred to the 'Forward.' During the voyage all our cases
were kept with the mail bags, except the box containing
chemicals, plates, &c., which was stowed in the front saloon.
Mr. Rooney left this morning at 11 A.M., in H.M.S. 'Forward.'
They are to take soundings on arrival to prepare us a snug
berth. We are looking up tents, and hope to join the 'Forward'
at Salut Isles on December 7, leaving a full week for erecting
instruments, and another for rehearsals. I have given Mr.
Rooney instructions about choice of site and foundations of
instruments, and as 'Forward' takes cement and bricks, we hope
to find things advancing on the 7th. . . . All are most kind and
anxious to assist in every way."

One other letter was received from Father Perry, dated
1889 December 12. He says :—

"I wrote from Barbados up to date December 2. H.M.S.
'Forward' sailed on November 28, and soundings, pilot, &c., were
all ready for us when we sighted the Salut Isles on December 7.
H.M.S. 'Comus' anchors within less than half a mile of the shore
so we are always well within reach of aid of every sort. The
Governor of Cayenne had received the fullest instructions
from his Government, and is anxious to render us every assist-
ance The Commandant des Isles du Salut enters most fully
into all our plans, and is most kind and attentive to our wants.
Everything so far has been more satisfactory than we could have

hoped. The weather is magnificent, but terribly hot. We have chosen an excellent site on Royal Island, and erected four tents: two large tents for the instruments, and two bell tents, one for the empties, and the other for chronometers, theodolite, &c. Concrete foundations have been laid for the mirror and lens, and a firm bed for the seconds-clock. Mr. Common's instrument will rest on a bed of concrete that would be firm enough for a standard observatory; the nuts have been set this morning, and I hope to get the whole instrument in position this afternoon, with the exception of the mirror. Mr. Rooney's corona-graph is well mounted on a solid foundation, and I expect to get its position accurately this evening. Our photographic dark room is one of the convict cells, and when the carpenters have completed their work, we hope to have a most convenient room. At first we excluded the light very effectively, but the air was lost as well, and then lamps and candles refused to burn.

" The water supply is good, and we have fortunately found everything uninjured in the boxes already opened.

" I took two photographs yesterday and the plates showed no signs of frilling, in spite of the high temperature of the water. We have no ice here, but some may perhaps be procured from Cayenne. Mr. Rooney enjoys robust health, but I have had a very slight touch of fever, and am taking quinine and sulphur baths. We have excellent quarters in the military hospital, and all the officials on the island are devoted to our interests. I need scarcely say that Capt. Atkinson and the officers and men of H.M.S. 'Comus' could not be more kind or take a greater interest in the success of our observations."

On 1890 January 3, the following telegram was received from Mr. Rooney :—

" 104 Corona American Perry dead dysentery."

The figures 104 are in the language of the cypher code pre-arranged for communicating results of the expeditions, which code is given below. The figures signify :—" Weather moderate, clouds ; exposure with the lens successful, development not ; exposure with the mirror successful, development not." It was rightly conjectured that the development was not attempted, owing to the illness of Father Perry ; the plates were brought to England for development by Mr. Rooney.

The words *Corona American* signify that the Corona was generally of the same form as that shown in the American photographs of the Eclipse on 1889 January 1. The remaining words refer to the death of Father Perry from dysentery on December 27; his body was landed at Demerara on December 28, and buried by his old friend and pupil the Archbishop of Demerara. Mr. Rooney returned to England by the R.M.S. " Eden," bringing with him the instruments and plates (undeveloped)

taken during the eclipse. He called at the Royal Observatory, Greenwich, on 1890 January 21 and 22, bringing the plates, and notes &c. by the officers of H.M.SS. "Comus" and "Forward."

These notes were as follows :—

1. A Report by Lieutenant John F. Mills, R.N., showing the running of the driving clocks by the R.A. circles and a chronometer, on December 19–22. The driving clocks were apparently going well on the morning of the eclipse. Also a record of the temperature during the eclipse ; remarks on totality, weather, &c.—(See below.)

2. The cards issued to the time-keepers. These are simply a series of bold figures, beginning at 135 and decreasing to 1. On the signal being given for totality. the observer at the chronometer counted backwards in a loud voice, beginning at 135 (135 seconds being the computed duration of totality). The recorders crossed out on these cards the number being called when an exposure was made or completed. There were three independent recorders to each instrument, and at least two of them agree in every instance, the third sometimes differing by 1 sec.

The records are as follows, the first number being always supported by two records :—

Lens.		Mirror.	
Secs.	Secs.	Secs.	
130 (or 129) to 125		135 (One second)	
			Secs.
120	to 111	123 (or 124) to 119	
106 (or 105) (One second)		107	to 97
100	to 90	86	to 66
70	to 51	51	to 11
45 (or 44)	to 7	And after totality, marks representing instantaneous photographs at 8, 30, 60, 90, 120, 150, and 189 (or 190) seconds after totality.	

3. Officers' Reports and drawings of Corona, notes of which are appended.

The plates were immediately taken by me to the Society's rooms and deposited with Mr. Wesley. They were all packed together and hermetically sealed. They were removed by Mr. Common to Ealing, where he developed the plates taken with the 20-inch mirror. The others were handed over to Captain Abney, who developed them. The following brief description of the plates obtained was drawn up by Mr. Wesley :—

Photographs taken with 4-inch Lens.

No. 1. (Exposure 5 sec., but with reduced aperture ; equal about to ¼ sec. full aperture.) Very little Corona, but

prominences on E. side very well shown and in perfect focus. Plate absolutely clear and free from spots.

No. 2. (Exposure 10 sec., with reduced aperture; equivalent to $\frac{1}{2}$ sec. full aperture.) Three or four separate exposures overlapping : in all other respects same as No. 1.

No. 3. (Exposure 1 sec., full aperture.) Clear plate without spots; shows same prominences as 1 and 2, but a little elongated through a slight shift. Corona can be traced to rather more than $\frac{1}{4}$ diameter from limb.

No. 4. (Exposure 20 sec., full aperture.) Corona can be traced to $\frac{1}{2}$ a diameter from limb; shows some detail, but interfered with by white spots; prominences on E. limb only. Corona near edge of plate.

No. 5. (Exposure 10 sec., full aperture.) Greater extent of Corona, but plate spoiled through a considerable shift. Shows prominences on E. limb and trace of one on W. ?

No. 6. (Exposure 40 sec.) On the whole, the best of the plates. Corona dense, extending to not quite a diameter from limb : coronal details can be made out, but they are not very definite. Chromosphere showing strongly on W. limb; reversed on most intense part.

Photographs taken with 20-inch Mirror.

No. 1. (Exposure 1 sec.) The merest trace of the limb.

No. 2. (Exposure 5 sec.) Corona extends nearly $\frac{1}{2}$ diameter from limb in some parts. Very thin negative : shows a little detail to the S.; in other places much interfered with by spots. Very faint trace of prominences on E. limb.

No. 3. (Exposure 10 sec.) Corona extends $\frac{3}{4}$ diameter from limb to E. and N. Thin negative; extremely spotty; shows some details at poles very well. Prominences on E. limb seem *reversed* in a very singular manner.

No. 4. (Exposure 20 sec.) Corona extends rather further than in No. 3, but the plate is so much spotted and scratched that less detail is shown. Prominences on E. limb and lower parts of Corona to E. and W. are *reversed*, yet the negative is not very dense.

No. 5. (Exposure 40 sec.) Corona possibly extends nearly a diameter from limb, but plate fogged and *very much* spotted; detail scarcely visible. Prominences on both limbs and lower portion of Corona sharply reversed, but limb very clearly defined.

No. 6. (Instantaneous, taken 8 sec. after totality.) Shows portion of reappearing crescent, sharply reversed. The whole limb of Moon visible, with trace of Corona.

Nos. 7–12, taken 30, 60, 90, 120, 150 and 190 seconds after totality, show the reappearing crescent sharply reversed and doubly reversed, but no trace of Corona or Moon's dark limb.

Captain Abney writes on January 29 :—" I finished develop-
ing the [lens] plates this evening. To begin with, the plates
have suffered slightly from having been repacked with damp
paper *in contact* with the films, and as a consequence the scales
on the plates are useless. I developed the 20-second photograph
first, and found the scale bad, so I developed fresh scales exposed
on the same *batch of* plates with each of the remaining Corona pic-
tures, so they are all right for measuring. The plates are rather
spotty, owing to the repacking. They ought to have been re-
packed as sent out. The plates which I had at home not tinned
up, but in grooved boxes, are spotless.

" Now for the photographs themselves :

No. 1. (=¼ sec.) Very good; prominences sharp and very
    little halation; very good for drawing and for measuring
    the brightness close up to the limb.
No. 2. (=½ sec.) Three distinct images of the limb; very
    useful for showing the inner Corona.
No. 3. (1 sec.) Good; less extension than in No. 4.
No. 4. (10 sec.) An excellent photograph. Not so much exten-
    sion as in No. 6, but by reflected light very nearly so.
No. 5. (20 sec.) The clock evidently went wrong in this: a
    blurred image, but useful for drawing.
No. 6. (40 sec.) I should say the full Corona developed.
    Evidence of a very bright sky as well.

" From a casual examination I should say that the Corona
close to the limb is about 200 times brighter than the Corona
½ diam. away. There will be lots to do in the measurement
which will make this eclipse very valuable, I think, though the
photographs are not as good technically as they might have
been. There is very little structure in the Corona."

Mr. Common remarks :—" I am very strongly of opinion that
the mirror was dewed." This seems to be very probable. The
cotton wool placed over the mirror in repacking was found
quite damp when the hermetically sealed tin case containing it
was opened at Greenwich, and Mr. Rooney says that it was
almost impossible to keep things dry. The mirror was seen to
be dewed on opening the telescope before the eclipse and was
turned towards the Sun at once; but it is very doubtful whether
its reflecting surface would even in an hour absorb enough heat
to dry off the dew. Father Perry, who had charge of the
mirror, was not able to come to his instrument till late, and it is
quite possible that the dewed state of the surface was over-
looked. The conspicuous failure in photographic power shown
in the short-exposure plates with the mirror, is strong evidence
of an anomalous condition of the surface.

The *objects of the expeditions* were stated in the last Report to be threefold :—

I. To detect any possible changes in the Corona during the $2\frac{1}{2}$ hours that elapse between the dates for totality at the respective stations.

The failure to obtain results at the South African station disposes of this point.

II. To photograph the coronal extension as far as possible.

It cannot be said that any definite conclusion has been arrived at with regard to the extension. It is almost certain that for some cause the 20-inch mirror was not efficient on the occasion of the eclipse, and it is probable that it was dewed. With an effective aperture of 15 inches the short-exposure plates should have shown much more if the mirror had been in its normal state. Hence the failure to photograph the Corona more than about a diameter from the limb in 40 seconds cannot be taken as evidence against the possibility of photographing " the extension " in the future.

III. To determine the photometric intensity of the Corona.

Captain Abney's care in developing new plates with standard squares on them at the same time as the eclipse plates has rendered this feasible. He has expressed his willingness to undertake this part of the work, and it only remains to place the plates in his hands for the purpose.*

I would suggest also that Mr. Wesley be asked to make a drawing of the Corona from the two series of plates.*

Some photographs were also taken with the mirror after totality at the suggestion of Captain L. Darwin and Dr. Huggins, and are referred to above.   I would suggest that Dr. Huggins be asked to examine these.*

The remaining sections of this Report are as follows :—

B. Mr. Taylor's Report.

C. Mr. Rooney's Report, which he has kindly prepared for us, although he did not originally undertake work for the Society.

D. A summary of the notes made by the naval officers, &c.

E. The cypher code referred to above.

B. *Mr. Taylor's Report.*

The expedition to South-west Africa for observing this eclipse left Liverpool in the Royal Mail steamer " Bonny," of the British and African Steam Navigation Company, Limited, on October 9, and arrived at St. Paul de Loanda on November 16,

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* Recommended to the Council and adopted.

touching at Grand Canary, Sierra Leone, and other important places on the voyage.

Immediately on arriving at Loanda I placed myself in communication with Mr. Edward Bannister, the Acting British Consul for the province of Angola, and by his exertions it was arranged to land the instruments without examination by the Custom House authorities. His Excellency the Governor-General of Angola very much facilitated the arrangements in Loanda, and very kindly offered his services if he could in any way assist the expedition.

The instruments were landed at Loanda on November 18 and stored in the warehouses of Messrs. Newton, Carnegie & Co., pending the arrival of the gunboat to convey them to the eclipse station. It had not been decided before the expedition left England which ship of the Cape Squadron could be sent to assist at the eclipse station, but while at Bonny I heard from the late Commander Pullen, R.N., then with the gunboat "Alecto" engaged in determining the latitude and longitude of Bonny, that H.M.S. "Archer" would be sent to assist the expedition. Admiral Sir Richard Wells also telegraphed from the Cape to Loanda telling me I might expect the "Archer" on December 10. The eclipse station at Cape Ledo being in an unexplored district, where the natives were hostile, according to the Portuguese authorities in Loanda, and where great difficulties in landing were expected owing to surf, I did not consider December 10 would allow sufficient time for preparations, and telegraphed to Admiral Wells to that effect. He immediately ordered the gunboat "Bramble" from Fernando Po to Loanda to assist the expedition, and hurried on the "Archer" from the Cape of Good Hope with the tents and stores. The "Bramble" arrived at Loanda on December 2, and the "Archer" on December 4. Commander Ferris of the "Archer" immediately placed either ship at the disposal of the expedition. After consultation it was decided that the "Bramble" should assist, and the tents and instruments were at once placed on board. Early on the morning of December 5 the "Bramble" started for Cape Ledo, anchoring in Mastote Bay under shelter of the Cape late in the same afternoon.

Next morning Lieutenant and Commander Langdon of the "Bramble" and myself explored the district round Cape Ledo, but could not find any trace of "Antigas Factories," which are marked on the chart as being exactly on the central line of the eclipse. No one in Loanda had heard of these factories, and we found that no such place is in existence near Cape Ledo. We were very fortunate, however, in finding a splendid station on the plateau near Cape Ledo, landing and access to the plateau being comparatively easy at this place, although quite impossible at any other point for at least ten miles north of the Cape. The latitude of the station was ascertained, the sites of the instruments fixed, and the ground cleared immediately.

The landing of the instruments was scarcely interfered with by the surf, thanks to the surf-boat kindly lent to the expedition by the Governor-General of Angola, and everything had been safely carried to the station, about 400 yards inland, by December 10.

Concrete blocks were set in the loose sandy soil to serve as supports for the bases of the instruments, and the erection of the photoheliograph with the 4-inch lens at once proceeded with. It and the 20-inch reflector were erected by December 14, the weather up to this time being very unfavourable for astronomical work. During the next week the weather was generally cloudy, but the few clear evenings enabled the necessary adjustments to be made and the focus to be accurately fixed by means of star photographs with each instrument.

Lieutenant and Commander G. F. Langdon took charge of the 20-inch reflector; Chief-Engineer W. Lonnen, who had some previous experience in photography, undertook to photograph the Corona with an ordinary quarter-plate camera; while the photoheliograph with the 4-inch lens was reserved for myself. Dr. Beatty had charge of a 3-inch telescope (kindly lent by Professor David P. Todd, of the American Expedition, at Cape Ledo) and undertook to make a drawing of the Corona. Lieutenant G. W. W. Dawes and Chief-Gunner Looman undertook to call the time during totality. Complete rehearsals of the whole of the operations of the eclipse were held on the four days preceding the day of the eclipse.

Experiments were made during the four days before the eclipse with the different plates and developers sent out. On the whole Mawson and Swan's extra sensitive dry plates were found to give the best results with all the developers tried, and I decided to use these plates for the photographs with the mirror. Successful pictures for orientation were obtained at 3 o'clock on December 21.

The evening of December 21 was clear, and star photographs were taken as a final check on the focussing of the instruments. These were very satisfactory. The sky clouded at about 10 o'clock on the night of December 21, and remained cloudy during the whole of the next day. At 10.45 A.M. on December 22, a slight shower of rain rendered it necessary to cover up the instruments. Towards noon the sky improved, but approaching the time of first contact the clouds again thickened. At $1^h 29^m 35^s$ P.M. local mean time, I noticed through a break in the clouds that first contact had taken place. As totality approached the Sun was seen through occasional breaks, but never for more than half a minute. Clocks were wound and started, caps and stops removed, and everyone was ready 15 minutes before totality. Thick clouds now covered the Sun, while the darkness increased rapidly, "two or three rapid bounds of darkness" being noticed.

When the eclipse became total the clouds round the Sun assumed a leaden colour, and a patch of blue sky to the east

became purple, but at no time was the darkness very intense. The clouds near the horizon reflected sufficient light to enable the chronometer minute and hour hands to be seen at 8 feet distance, and the second hand to be seen at 3 feet. The white tents of the American camp about half a mile distant were distinctly visible. Before totality the wind had entirely ceased, but a distinctly cold wind blew from the south-west during totality. Lieutenant Dawes noticed just at the end of totality that " the western sky seemed very dark, and after a few seconds it suddenly brightened, the darkness seeming to pass away across the eastern sky." No trace of the Corona was seen and no exposures were made with either instrument during totality. The end of totality was noted owing to the sudden breaking out of the light, but the Sun itself was not seen for 20 minutes after that time.

Immediately after the eclipse the instruments were dismounted, packed, and conveyed on board the " Bramble," which left for Loanda early on December 23, arriving there in the afternoon. The return voyage to Liverpool was made in the s.s. " Cameroon," which left Loanda December 27, and arrived in Liverpool on February 20.

The officers and crew of H.M.S. " Bramble " worked in a manner beyond all praise during the whole of the operations at the eclipse station.

The courtesy and assistance of His Excellency the Governor-General of Angola have already been referred to. The best thanks are also due to Mr. E. Bannister, the Acting British Consul at Loanda, and to Messrs. A. Nightingale and W. S. Brock (of Messrs. Newton, Carnegie & Co.), for their kindness and assistance at that place; also to Commander Ferriss of H.M.S. " Archer " for his valuable assistance at Loanda. I must also recognise the kindness and generosity of Messrs. Elder, Dempster & Co. and their agents along the coast for their kind offices on the voyage to Loanda and back.

<div align="right">A. TAYLOR.</div>

Ealing :
  1890 *March* 11.

C. *Mr. Rooney's Report.*

In obedience to instructions received from the Committee of the Royal Astronomical Society, the Rev. S. J. Perry and his assistant, Mr. J. Rooney, sailed from Southampton on November 14 in the R.M. ship " Tagus," Captain Brander, for Barbados, en route for the Iles du Salut, to observe the total eclipse of the Sun on the morning of December 22. After a fair passage we reached Barbados at 6 A.M. on November 26. Here we found H.M. ships "Comus" and "Forward," under orders from the Admiralty to conduct us to the place of observation. At 9 A.M. Captain Atkinson and Commander Gray came on board the " Tagus," and after a consultation it was arranged that Commander Gray should take

Mr. Rooney and the instruments, tents, &c., on board the "Forward," and sail on the 28th to the Iles du Salut. The Commander was instructed to take soundings near the islands so as to secure safe anchorage for the "Comus," and come out with a pilot to meet that vessel on her arrival, which was fixed for December 7. Mr. Rooney was to select a site for observation, and get the instruments landed. Accordingly on the 28th, at 11 A.M., the "Forward" sailed, and after a rough passage the islands were sighted on December 5 at 10 A.M., and at 4 P.M. the vessel was anchored about a quarter of a mile from the main island. The Iles du Salut are a group of islands off the coast of French Guiana, about twenty-two miles from Cayenne, and twelve miles from the mainland. They are used by the French as a penal settlement for convicts from their colonies. The group consists of three islands, the largest of which is Royal Island, on which the commandant and chief officials reside. Here also are two large hospitals, one for the military, the other for the convicts. There are 700 convicts on this island, 150 being French, the rest Arabs, Mahometans, and Chinese. They are guarded during the day by 40 warders, who always carry loaded revolvers, and at night by 60 infantry. The other two islands are "St. Joseph's," where political prisoners are detained, and the "Devil," where lepers reside. These latter are supplied with food twice a week, and receive an occasional visit from the doctors.

Soon after the "Forward" had anchored, Dr. G. Dufour came on board, and then Commr. Gray and Mr. Rooney went to pay a visit to the commandant, and were most cordially received. He informed us that orders had been sent out by the French Government to give the observers every assistance possible. He therefore put the convicts' labour at our disposal, and had already prepared four rooms for us in the officers' quarters of the military hospital, a very fine building. On the following day Mr. Rooney discovered an excellent site for the observatory in a disused garden, with a clear horizon from N. to S.S.E., and protected on the W. and S.W. by a wall. On the morning of the 7th Mr. Rooney and Dr. Jacks, of the "Forward," landed on the Royal at 5 A.M., and from the spot selected the previous day they sighted the pole star, and took the position of the Sun at rising, and with the help of a compass marked the cardinal points on the ground by sinking stones into it. This precaution was taken to prevent the marks being washed away by the heavy rains. As the site promised to be in every way most satisfactory, the instruments were landed, and the "Forward" set out at 9 A.M. with a pilot to meet the "Comus," which was sighted at noon, and brought to a safe anchorage under the lee of Royal Island, about half a mile from the shore, by 3 P.M. Father Perry and Captain Atkinson landed at 4 P.M., and were received at the landing-place by a bodyguard, which escorted them to the commandant's residence. The commandant, M. Ferdinand Leloup,

received them most kindly, and repeated the instructions received by him from the French Government. The site chosen for the observatory was then visited, and the rooms at the hospital; and Father Perry expressed his great satisfaction with both. On his requesting the use of some place that would serve as a photographic dark room, a condemned cell was at once placed at his service. On Monday morning, December 9, Lieutenant Thierens, with a party of about twenty men, landed, and with the assistance of the convicts carried the instruments, tents, &c., to the chosen site, which was about 200 feet above sea level. By night all the tents were erected, and the foundation for the 20-inch mirror was started, and all the photographic materials were unpacked and arranged in the condemned cell. Father Perry gave a lecture on Solar Eclipses, which was illustrated by slides projected on the screen by means of a magic lantern. This took place on board the "Comus," in the presence of the officers and men of the two ships, and at the end he read out the names and duties of those who had kindly volunteered their services during the eclipse. On the morrow, the 10th, the "Forward" sailed for Bermuda. The foundations for the stand of the 4-inch lens and the seconds clock were ready by the 12th, and the stand and base-plate were mounted.

In order to fix the polar axis with the greatest possible accuracy, Mr. Rooney, assisted most ably by Lieutenants Thierens and Mills, made use of the following method. Instead of sighting the pole star by means of the sockets alone, which carry the polar axis, a piece of brass was inserted in each of them, one with a small round hole, and the other with a cross cut out of it. At its culmination the pole star was sighted through these two apertures, and the instrument moved until the star was visible in the centre of the cross. The instrument was next adjusted for latitude, and as soon as the exact position was obtained, cement was placed round the back leg of the stand, which had been fixed in the foundations in a hole four inches deep. After allowing a night to intervene, the instrument was again tested for latitude and level, and found to be quite accurate; hereupon the two fore legs were secured with cement, and a covering of soil, about twelve inches deep, was placed round the legs to prevent displacement. The instrument was then completely mounted; but it was found that the slides and shutter had warped and would not work. This defect was soon remedied by the carpenter, and on the night of the 14th some trial photographs of the stars were taken. After four plates had been exposed, it was found that the brass circle, for clamping in declination, was broken. This stopped the work for the night at 11 P.M.

On Monday, 16th, at 3 P.M., the clamp was repaired and the instrument remounted, and the first full rehearsal fixed to take place at 4.30 P.M. The instruments to be used were a silver-on-glass mirror, 20 inches aperture and 45 inches focus,

by Mr. A. A. Common, F.R.S., and a lens 4 inches aperture
and 5-foot focus, the property of Captain Abney, R.E., F.R.S.
Father Perry took charge of the former, and Mr. Rooney of the
latter. The observatory camp was an oblong, some 30 yards
by 20. In this the instruments were placed diagonally, 15 yards
apart, with the seconds clock midway between them. The Simms
transit theodolite, from Stonyhurst Observatory, was used by
Lieutenant Mills to get the latitude and longitude of the station.

The programme drawn up by the Solar Eclipse Committee of
the Royal Astronomical Society was as follows:—With the
mirror five exposures were to be made of 1, 5, 10, 20, 40 seconds
respectively, with others at discretion. With the lens six ex-
posures were to be made, two with 1-inch diaphragm, of 4 sec.
($=\frac{1}{4}$ sec. full) and 8 sec. ($=\frac{1}{2}$ sec. full), and four with full
aperture of 1, 5, 15, 40 seconds respectively; two others might
be made at discretion.

At the rehearsals, as on the day of the eclipse, there were four
assistants at each instrument, three officers to note down the
exact second called by the timekeeper when each plate was
exposed and when the exposure was completed, and one first-
class petty officer to give out the plates in order, and after
exposure to place them in the receiving dark box. The time-
keeping was entrusted to Dr. Axford, R.N., and the yeoman of
the signals. It was the duty of the former to count seconds
from a chronometer for three minutes before totality, and
immediately totality commenced to give the signal to the latter,
whose duty it then was to set the clock going and begin to count
the seconds in a loud voice, beginning with 135 and counting
backwards to o. The structure of the Corona was to be observed
by Captain Atkinson with a small telescope, kindly lent to
Father Perry by General J. F. Tennant, R.E., F.R.S., whilst a
similar observation was to be made by Lieutenant Thiereus with
the naked eye.

At each instrument two blue-jackets were stationed with
lamps, and two sentinels were placed on guard with strict orders
not to allow anyone to enter the camp during the rehearsal.
Chief-Engineer Ellis was in attendance, to offer his services in
case they were needed. At the first rehearsal great confusion
prevailed, chiefly on account of the inaccuracy in counting the
seconds. This was partly owing to the fact that a deck watch
had to be used, as the seconds clock was found to have been
seriously damaged during the voyage. After a second lecture
which Father Perry gave that evening he pointed out improve-
ments which might be made on the first rehearsal. On the 17th
a second rehearsal took place, but although the seconds clock
was in use it was not in good working order, and the rehearsal
was not a success. On the 18th the rehearsal went off very
smoothly, the seconds clock being in very good order. As it was
desirable to hold a rehearsal as far as possible under the circum-
stances which would prevail during the eclipse itself, another was

held on the 19th at 6 P.M. in twilight, and no confusion was
caused by the darkness.   At 9 P.M. the same evening rain began
to fall in torrents, and continued all night, so that no trial photo-
graphs could be taken.   On the 20th at 9 P.M. the stars shone
out most brilliantly, and Father Perry decided to remain in the
observatory all night to take trial photographs.   On developing
the first plate exposed with the mirror it showed that the in-
strument was very much out of focus, but after exposing and
developing nine other plates the focus was secured.   The sky
then became clouded at 2.30 A.M., so Lieutenant Thierens and his
men returned to the "Comus" for the night.   As Father Perry
thought that it might clear up again, and he wanted to get a
few more photographs if possible, and as he wished to sight the
position of the Sun at its rising, he lay down in his hammock
under one of the bell tents instead of going to his quarters at the
hospital.   Mr. Rooney did not like the idea of sleeping there, so
he walked about the camp.   It is thought that Father Perry got
a chill on this occasion, for the dew falls very heavily during the
night on the Salut Isles.   At 5.45 A.M. Father Perry got up and
prepared to take the Sun's position, in which he succeeded
about 6 A.M.   The party from the "Comus" arrived at 6.45 A.M.
To secure the orientation of the plates photographs of the Sun
were taken by both instruments, using a pinhole aperture with
the telescopes clamped and clocks not driving, at intervals of a
hundred seconds, on the same plate.   It had been arranged that
these photographs should be taken on the days before and after
the eclipse, at the local time at which the eclipse took place.
Two plates were exposed at each instrument, and after the
rehearsal, which took place at 7.30, these plates were developed,
and it was found that the two taken by the lens were good, but
those taken by the mirror were a failure, as no trace of an
image appeared on the plates, owing, it is thought, to the pin-
hole aperture being too small.   It was decided that while the
astronomers were taking a little repose a new diaphragm with a
larger aperture should be made by the engineer.   This was ready
at 3 P.M., when a successful photograph of the Sun was taken
with the mirror.   Further arrangements for the morrow's obser
vation were then made, and the instruments were prepared to
take photographs of the stars after dark, but the sky was over-
cast, with heavy rain, so after the chemicals, &c., had been got
ready in the dark room, and everything was complete and in
good order for the 22nd, the astronomers retired to their
quarters for the night.

At 3.30 A.M. Mr. Rooney hearing Father Perry moaning
entered his room and found him in great pain.   He gave him a
dose of some medicine which they had brought with them, and
this seemed to give him some relief.   Before Mr. Rooney left
Father Perry requested him to send a blue-jacket to assist him
over the rough road to the observatory.

At 4.45 Mr. Rooney started for the observatory, to get every-

thing ready and put the plates into the slides. Eight of Captain
Abney's specially prepared plates were placed in two single dark
slides, four in each, for the lens, and twelve of Ilford's ordinary
plates were placed in six double slides for the mirror. Numbers
to indicate the order of exposure were marked with a writing
diamond on the left-hand top corner of each plate. Each slide
was put in a separate black bag, marked with a bold white
number corresponding to that of the slide. These bags were
then put in zinc-lined boxes, one for each instrument, which
were then carried to the camp.

At 6 A.M. Lieutenant Thierens and his men arrived. The
officer was informed of Father Perry's illness and request, so a
man was sent off at once. The Sun rose in a clear sky, but at
7 o'clock all looked very black, and at 7.20 a heavy shower of
rain fell, and Mr. Rooney got both instruments covered with
tarpaulins, but left them in position, and allowed the clocks to
run. The shower over, he had the tarpaulins removed, and
looked to the lens and saw that both instruments were still in
position.

As Father Perry had not yet arrived, Mr. Rooney suggested
to Captain Atkinson that as Lieutenant Thierens had assisted
Father Perry at the mirror during the trials, he should take
charge of that instrument. This arrangement was agreed to,
but whilst a consultation was taking place to settle which expo-
sures it would be best to secure, Father Perry was seen coming
down the hill leaning on the blue-jacket. On his arrival in the
camp he asked Mr. Rooney if everything was ready, and being
told that all was quite ready, he walked round to see that every
man was in his place, and at the appointed time gave the signal
to wind clocks, &c.

The sky brightened up a little, and there was a large patch
of blue near the Sun; a few minutes later the Sun appeared, it
being then a little more than half eclipsed, and about seven or
eight minutes before totality commenced the Sun was well
out into the blue patch. The writer of this report will now con-
fine himself chiefly to what occurred at his own instrument.

I watched the image on the ground glass, and saw that it
was beautifully sharp and clear.

About 30 seconds before totality I told Mr. Davis to put in
the inch diaphragm; accordingly the dew cap was removed and
the diaphragm inserted, then the dew cap was replaced. The
dew cap was 12 inches long. The reason why I did not get the
diaphragm inserted sooner was because on several former occa-
sions I had put it in before running the instrument on the Sun,
in order to protect the lens, and I always found condensation on
the lens when the diaphragm was removed. I then put in the
slide and removed the ground glass, and awaited the signal to
begin. After the second exposure, I waited a second or two
until the instrument got steady after the removal of the dia-
phragm, and this precaution I adopted each time after changing

the position of the slide. I had just closed the shutter after the
40 sec. exposure on the sixth plate when the signal for the end of
totality was given. I had thought of exposing the seventh plate
very rapidly, but finally decided that, as the slide had been so
carefully protected from the light so far, it would be better to
run no risk from the bright sunshine, and therefore I at once
removed the slide, and put it into its black bag, and then into
the zinc-lined box. Had the totality lasted 135 seconds, as I
expected, I should have been able to expose the two additional
plates, but as it lasted only 129 I was just able to secure the six
exposures on the programme. The sky round the Sun was clear
some seven or eight minutes before and after totality. I noticed
that the Corona stood out magnificently, and the prominences
were very marked. I saw at once that it was very much like
the American one of January 1, 1889, a photograph of which I
had seen, and a positive of which was projected on the screen
during the lecture on the " Comus." *Jupiter* and *Mercury* were
quite visible during totality.

At my instrument lamps were not needed at all, as I
had previously marked the slides with bold labels, on which I
had marked the number of the plate and the amount of exposure.
When the eclipse was over, the plates were taken to the con-
demned cell and locked up.

At the end of the observation Father Perry walked over to
me and asked me if everything had gone right at my instru-
ment. I replied that everything had gone on most satisfactorily.
He then said, "This is the most successful observation of the
kind that I have ever had anything to do with." He then
asked Captain Atkinson to get the men to give three cheers for
the successful observation, and three hearty cheers were given.
He said, " I cannot cheer," but he waved his helmet.

From the moment he entered the camp until the observa-
tions were all over he seemed quite himself, and everybody
hoped that he was not so ill as was feared; but it was with
great difficulty that I got him up the steep hill back to our
quarters. Frequently on the way he spoke of the providential
manner in which the sky cleared and enabled us so successfully
to photograph that for which we had travelled so far. He con-
sidered the toils and fatigues well repaid by the magnificent
sight we had just beheld. When we reached the hospital he
was quite exhausted. I asked the resident doctor to come and
see him. He said he was very feverish and very much fatigued.
The doctor told him to remain in bed and await some medicine.

Father Perry told the marine to pack up all his things, and
he wished me to go on board the " Comus " to take some rest
to be ready for the work of the morrow; he also wished me to
ask Captain Atkinson that a boat might be sent for him at five
o'clock that evening, and a man to help him down. All was
done as he wished, and at 5.45 P.M. he arrived on board the
" Comus." He was met by Dr. McSwiny, the staff surgeon of

the " Comus," who immediately reported to Captain Atkinson how serious the case was. The next morning it became clear that he was suffering from the very worst form of dysentery. I went to his cabin at 6 A.M., before starting for the observatory, when he told me to get the plates which had been exposed the previous day put into the zinc case and sealed up, as we should not develop them at the islands. I went on shore, and with the assistance of Lieutenants Thierens and Mills got both instruments ready to take the pinhole photographs, but the sky was overcast the whole morning. I reported this to Father Perry on my return, and he decided to dismount the 4-inch lens and to leave the 20-inch mirror standing until Tuesday morning, to make another attempt to secure a pinhole photograph. Meanwhile the doctor had pronounced Father Perry's life to be in danger, and the captain and doctor both thought it best to dismount the mirror and get everything packed and on board that day, and to start next morning, the 24th, with all despatch for Demerara. Father Perry assented to this, and additional help was sent on shore, and by 6.30 P.M. everything was safe on board. The next morning was overcast with rain, so that no photographs could have been taken, even if the instruments had been left standing. Father Perry had so bad a night that the order to sail was cancelled.

The weather on the 25th was fine but cloudy, so that no photograph could have been taken. Father Perry was a little better, but it was a very quiet Christmas Day for all on board. There was a piano in the ward room, but it was never touched during Father Perry's illness. The captain and Dr. McSwiny were anxious to get away, for there were men down with the same malady, and many others more or less unwell. Father Perry was consulted, and he consented to be put in a cot and incur the additional risk of sea-sickness in order to reach the Bishop and his confrères in Demerara. The Abbé and Commandant boarded the "Comus" to say good-bye. So on Thursday morning a start was made for Demerara. Father Perry passed a quieter day. Being asked by me if he felt the motion of the ship he replied that he was very comfortable. Towards night he grew worse, and Dr. McSwiny and Dr. Axford divided the night watch between them. In fact, they were unremitting in their attention. The night and day were divided into watches of four hours each, which were taken by the two doctors and myself. During my watch on Friday morning Father Perry gave me instructions to make out the telegram to be sent to Greenwich. He also wished me to take charge of everything after his death, and to hand the results of the expedition to Mr. Turner, the Secretary of the Solar Eclipse Committee. At 3.35 P.M. he lost consciousness, and became rapidly weaker, and peacefully passed away at 4.20 P.M. on Friday, the 27th. The body was carried by six marines to the bridge till the coffin was ready, in the cot in which he died, covered with a Union Jack.

At 10 P.M. the coffin was ready, and he was laid in it; his face quite calm and white, as if he was asleep. The coffin was left on the bridge. Father Perry died about seventy miles from Demerara, lat. 6·56 N., long. 56·50 W. At 3.30 on Saturday morning, 28th, we anchored two miles outside the lightship, which is itself twelve miles from Georgetown. The water being shallow, the "Comus" could get no nearer. Captain Atkinson sent a boat to the lightship to inform them of Father Perry's death, which they were to signal to the shore, and warn them to make arrangements for the funeral. Lord Gormanston, the Governor, with Bishop Butler, had met Father Perry in Barbados, and wishing him to lecture at Georgetown, had promised to send a steamer out as soon as the "Comus" was signalled. Before the lightship had received Captain Atkinson's message it had signalled the arrival of the "Comus," but owing to the mist it was unable to send the news of Father Perry's death. In the meantime his Excellency the Governor had sent a steamer, with Lord Gormanston's private secretary, Mr. J. F. Rawlinson, and Lieutenant Lingham, the harbour-master, aboard.

The steamer arrived at 9.30, and came as close as possible. At ten the captain ordered all hands on deck, and the same six marines who had carried the body before lowered it into the boat amid the solemn tolling of the ship bell. Father Perry had been a great favourite, and all on board seemed to feel his death very much. On the evening on which he died one of the blue-jackets came to me to say he was deputed by the other men on the lower deck to say how deeply they all felt his death. At 10.30 we steamed to Georgetown, and the "Comus," with her flag half-mast high, started for Barbados. On reaching land we found the Governor and the Bishop waiting to receive Father Perry, still ignorant of the sad reality. There was still some difficulty in arranging the funeral owing to objections raised by the officer of health; but it was finally settled that the body should be taken to the cathedral as soon as the grave had been prepared, and after a short service there to be carried at once to the cemetery. The Bishop received the body at the cathedral at two, accompanied by all the clergy. At 2.30 the cortège started. The body was carried to the hearse by six policemen, who walked by it to the grave. They were in charge of Inspector Gallagher. The Governor and his private secretary were present at the funeral. The prayers at the grave were said by the Bishop; the body of Father Perry was lowered into the grave at 4 P.M., December 28, 1889.

I sailed from Demerara on board the R.M. ship "Eden" on January 3, and arrived at Barbados on January 5, where I found the instruments, &c., which had come on in the "Comus." I left Barbados on January 6 in the R.M. ship "Medway," Captain Gillies, and arrived at Southampton on Saturday, January 18, and London January 20, and on January 22 handed to Mr. Turner the plates exposed, along with Father Perry's rough notes.

The greatest possible praise is due to Captain Atkinson and his officers and men for the hearty, earnest manner in which they threw themselves into the spirit of the expedition. Captain and officers were constantly inquiring if there was anything they could do to make us more comfortable and render the expedition a grand success. Lieutenant Thierens and his men deserve great credit for the able and cheerful manner in which they carried out each task that was entrusted to them. During Father Perry's illness on board the " Comus " the care of the doctors was most constant, and everything that it was possible to do for him was done.

I also wish to return my sincere thanks to Commander Gray, his officers and men, for the many acts of kindness I experienced at their hands during my stay on H.M S. " Forward."

<div style="text-align: right">J. ROONEY.</div>

Stonyhurst College Observatory:
    1890 *March* 10.

D. *Naval Officers' Reports, Notes, &c.*

(a) *Position of the Spot from which the Eclipse was observed:*

$$\left. \begin{array}{l} \text{Long. } 3^{h}\ 30^{m}\ 21^{s}\ \text{W.} \\ \text{or } 52^{\circ}\ 35'\ 15''\ \text{W.} \end{array} \right\} \text{Lat. } 5^{\circ}\ 16'\ 45''\ \text{N.}$$

Observer: Lieutenant J. F. Mills, of H.M.S. " Comus."

(β) *Time of commencement of Totality.*

$7^{h}\ 49^{m}\ 52^{s}\cdot5$, Local Mean Time.
Duration of Totality, 129 secs.

Observer: Lieutenant J. F. Mills.

J. K. Watson marks on a time-card the second numbered 6 as end of totality, 135 being the beginning.

The signalman similarly marks the second 9.

Mr. J. R. Hind, of the N.A. Office, kindly supplied the following equations for the neighbourhood of Cayenne:

$$\cos \omega = -0\cdot79283 - [1\cdot98752] \sin l + [1\cdot73085] \cos l \cos (\lambda + 132^{\circ}\ 5'\cdot7)$$

$$t = 1^{h}\ 16^{m}\ 56^{s}\cdot4 \mp [1\cdot83514] \sin \omega - [3\cdot32747] \sin l$$
$$- [3\cdot86213] \cos l \cos (\lambda + 74^{\circ}\ 18'\cdot5).$$

where

$l =$ Geocentric latitude of point.

$\lambda =$ longitude E. from Greenwich (here $-$).

$t =$ G.M.T. of beginning or end of totality.

With these equations and position given in (a) the Local Mean Time for commencement of totality is $7^{h}\ 49^{m}\ 57^{s}$, and duration 135^{s}.

(γ) *Tables showing the results of the running of the clocks attached to the Instruments by Comparison of the R.A. Circles with a Chronometer.*

(The latest observations only are given.)

F. Perry's Instrument (Mirror).					Mr. Rooney's Instrument (Lens).			
	Chronometer.		R.A. Circle.			Chronometer.		R.A. Circle.
d	h m s		h m		d	h m s		h m
Dec. 20	3 35 38		23 52		Dec. 22	5 28 8		4 35
	3 55 58		24 12			5 33 12		4 30
	4 8 10 5		24 24			5 38 23		4 25
Dec. 21	2 52 48		21 28			5 43 26		4 20
	3 1 26		21 32			5 48 18		4 15
	3 5 21		21 36			5 53 6		4 10
	3 9 14		21 40			5 57 46		4 5
Dec. 21	3 31 1		21 28		Dec. 22	6 37 49		4 25
	4 7 6		22 4			6 42 46		4 20
						6 47 57		4 15

Observer: Lieutenant J. F. Mills.

(δ) *Orientation of Plates, &c.*

Father Perry's Diary.—*December* 16.—[In absence of cardboard] Zinc cover made for mirror, with pinhole at centre:

5.30 tested perpendicularity of plate-holder to axis of tube with Sun; nearly correct; Sun too low before finishing. Tried at night with lamp, but could only confirm roughly.

December 17.—A very slight bending of the rods fastening the plate-holder made the reflected image of pinhole exactly coincident with direct image of Sun.

December 20.—Tried to get pinhole photographs, but clouds. Starlight night; mirror focussed by eye on ground glass and by photographs; the screws of the mirror are slightly short, so there is some danger in clamping at focus, only half the nut outside being available.

December 21.—Pinhole exposure at 7.49, but almost certainty of fogging.

New Zn plate for pinhole exposure, 1-inch aperture in same plate for 22nd.

Pinhole exposure poor.

[See also Mr. Rooney's Report.]

Lieutenant J. F. Mills' Report.—On the 23rd we tried to get pinholes with the lens and mirror at the same time as the eclipse had taken place the day before, but the Sun was not visible, and although it appeared a few minutes later for a few seconds, it was not bright enough to be of any use.

On the 24th it was just the same; in fact the day of the eclipse was the only day we had a bright Sun between 7.30 and 8.0 A.M. two or three days before, and after the eclipse, the Sun being behind the clouds at that time of the morning.

(ε) *Temperature during Eclipse.*

h m			h m		
7 40		78¼ F.	7 52	(Totality ends)	77
45		78	53		78
49		77½	55		77¼
50	(Totality begins)	77	8 0		78
51		77			

Observer : Lieutenant J. F. Mills.

(ζ) *Weather, &c., during Totality.*

"At 7.20 A.M. on December 22 there was a very heavy fall of rain, the sky being overcast and gloomy, and it only cleared a few minutes before the eclipse, but we were fortunate in having it clear at the time of the eclipse."—*Lieutenant J. F. Mills.*

(η) *Eye observations of Corona.*

Captain G. L. Atkinson, of H.M.S. " Comus," notes during totality :—"Very few streamers; no disturbance; rose-hued Corona; prominences exceedingly bright and conspicuous."

After eclipse : " The general appearance of the Corona was a circle of yellow and rose-tinted light, with streamers towards the equator, and through a telescope the Corona was like the eclipse seen in America this year. None of the streamers reached beyond one diameter of the Sun. The prominences were very bright and conspicuous. There was very little disturbance, and the Corona prevented an almost unvarying appearance during the whole of totality. The Corona was very uniform in construction, even at the poles, but at the equator the streamers were a little more prolonged. A squall of rain just before the eclipse cleared the air, and luckily passed over in time, giving us a grand chance of observing it. The appearance of surrounding objects during totality was as if one saw them through a neutral tinted glass. . . . I observed a rift in the Corona about 30° to the proper left of the Sun's zenith. . . . The light during totality was greater than upon a bright moonlight night, and the temperature was slightly affected. . . . During three days before and after the eclipse the Sun was not visible at the hour the eclipse took place."

Lieutenant H. W. Thierens.—" I have the honour to report with regard to the total eclipse of the Sun observed by me through a telescope, that I noticed nothing different from the

report of the eclipse observed by the Americans this year, except I noticed during totality a red shadow which seemed to pass from the right-hand upper corner round the bottom, and seemed to disperse at the left-hand corner."

Lieutenant J. Beville Pym.—" Shortly after 7 A.M. on Sunday morning, December 22, 1889, Sergeant George Lidbury, R.M.L.I., and myself were in our places at the tower on the top of the military hospital, Salut. The sky was cloudy in all directions, but especially to eastward, and we could see nothing of the Sun until 7.30 A.M. The clouds then lifted, and passed gradually over our heads to westward. Shortly before 7.45 a heavy rain-squall passed us on the north side, going westward. This, together with the thick clouds, completely hid the view to westward until some time after the eclipse was over. At 7ʰ 28ᵐ 5ˢ I observed a rainbow (bearing roughly W.S.W.) indistinctly through the clouds, and afterwards brighter.

" At 7ʰ 48ᵐ 5ˢ I observed the reflection of these clouds in the sea getting very black. I took the time of this, as I thought it must be owing to the approach of shadow before totality. I could not at this time see anything to westward but these thick clouds and the rain-squall.

" At 7ʰ 50ᵐ 8ˢ the whole face of the Earth became dark, and looking up at the Sun I saw that totality had commenced. [Drawing made during totality.]

" As soon as totality was over, and the light increased, I saw the shadow roll away and disappear to eastward at 7ʰ 52ᵐ 35ˢ, the sky being much clearer in that direction. I could see no shadows on the ground near me except those cast by natural objects before and after totality.

" Sergeant Lidbury says that just before totality the atmosphere appeared to him to be disturbed, and during totality he observed two spots on the limb of the Moon, the positions of which would correspond to the figures 4 and 8 in a clock. He also saw several colours round the Corona during totality."

Lieutenant A. H. Fanshawe.—" During totality observed long streamers, swallow-tailed at the ends, the sides being parallel and fairly hard lines ; the horizontal lines of light being about half the diameter in extent, and 2½ diameters in the long streamers. The long streamers were about 15° out of the vertical, the upper one to right, and lower to left. Also observed a bright star upon the right-hand upper quarter."

Mr. A. G. Yates.—" Before totality, when the Sun was about two-thirds obscured, I saw a few flashes of light straight to A (or even further), just like forked lightning."

[A is a point in the drawing five diameters from the limb, in the direction of the north point.]

E. *Cypher Codes.*

The code prepared for telegraphing general results was as follows :—

(Weather.)

The No.   1   represents   Weather good.

  „   2   „   Weather moderate : clouds.

(Lens Results.)

  „   3   „   Completely successful, both exposure and development.

  „   4   „   Exposure successful, development not.

  „   5   „   Exposure partly successful, development good.

  „   7   „   Exposure partly successful, development bad.

  „   „   No results.

(Mirror Results.)

  „   11   „   ⎫

  „   13   „   ⎪

  „   16   „   ⎬ Five alternatives just as for the lens.

  „   17   „   ⎪

  „   19   „   ⎭

Rule :—Select a number from each of the three divisions ; multiply the three together and telegraph the result. The number 104 actually received splits up into the factors $2 \times 4 \times 13$.

A second cypher was arranged for telegraphing the general shape of the Corona, but was not used ; it was as follows :—

Designate the directions E., W., N., S. by the prime numbers 2, 3, 5, 7 (more if necessary). Raise each prime to the power of the number of semi-diameters from the limb to which the Corona extends in the corresponding direction. Multiply the results together and telegraph the product.

Observations of the Moon made at the Radcliffe Observatory, Oxford, during the year 1889; *and a Comparison of the Results with the Tabular Places from Hansen's Lunar Tables.* By E. J. Stone, M.A., F.R.S., Radcliffe Observer.

The present paper contains the observations of the right ascensions and north polar distances of the Moon, made at the Radcliffe Observatory during the year 1889. These results are here compared with those deduced from Hansen's Lunar Tables on two suppositions :—

(1) That the mean times, found in the usual way from the sidereal times at mean noon, given in the *Nautical Almanac*, were *not* changed in 1864 by the adoption of a different unit of time.

(2) That these mean times *were* changed in 1864 by the adoption of a different unit of time to fix the positions of the clock stars relatively to the Sun, in accordance with the views which I have explained in papers communicated to the Society.

It will be seen that the mean annual error of Hansen's Tables from 1847 to 1863 is $-1''\cdot30$, and that no law of regular increase is apparent; but that, with the argument in the Tables taken out in the usual way, the mean annual error has since increased at an average rate of $0''\cdot72$ per annum, the error now amounting to more than $+17''$. The mean annual error of Hansen's Tables from 1864 to 1889 taken out with the *corrected* argument is $-1''\cdot36$, which is almost identically the same as the mean error between 1847 and 1863.

For facilities for an accurate comparison between Hansen's Lunar Tables and observations I am again indebted to the places published in the *Connaissance des Temps*.

TABLE I.

Radcliffe Observations of the Moon, 1889.

R.A.'s and N.P.D.'s of the Centre of the Moon, compared with Hansen's Tabular Places, Uncorrected and Corrected for the Change in the Unit of Mean Time introduced in the year 1864.

Day, 1889.	Correction to be subtracted from M.T. for change of Sidereal Time at Mean Noon since 1864.	Observer.	Observed R.A.	R.A. from Hansen's Tables for Uncorrected Mean Times.	Hansen minus Observed. Uncorrected.	Correction due to the Change in the Unit of Mean Time.	Hansen minus Observed. Corrected.	Observed N.P.D.	N.P.D. from Hansen's Tables for Uncorrected Mean Times.	Hansen minus Observed. Uncorrected.	Correction due to the Change in the Unit of Mean Time.	Hansen minus Observed. Corrected.
	s		h m s	s	s	s	s	o ' "	"	"	"	"
Jan. 12	37·15	F. B.	4 14 49·75	50·81	+1·06	−1·24	−0·18	72 38 32·39	29·21	−3·18	+4·37	+1·19
17	37·17	F. B.	8 40 36·35	37·74	+1·39	−1·35	+0·04	70 8 7·10	9·88	+2·78	−3·30	−0·52
21	37·18	F. B.	12 10 50·80	51·86	+1·06	−1·29	−0·23	85 46 47·87	53·49	+5·62	−7·65	−2·03
22	37·19	W.	13 2 30·51	31·63	+1·12	−1·30	−0·18	90 59 3·73	11·77	+8·04	−7·90	+0·14
Feb. 7	37·25	W.	3 6 57·58	58·62	+1·04	−1·20	−0·16	77 19 17·93	11·70	−6·23	+5·80	−0·43
8	37·26	R.	3 55 22·32	23·22	+0·90	−1·23	−0·33	73 46 57·63	52·34	·−5·29	+4·83	−0·46
9	37·26	F. B.	4 45 12·04	13·12	+1·08	−1·27	−0·19	70 57 28·47	25·41	−3·06	+3·64	+0·58
11	37·27	W.	6 29 50·34	51·24	+0·90	−1·35	−0·45	67 59 51·32	51·61	+0·29	+0·69	+0·98
12	37·27	R.	7 24 9·91	10·76	+0·85	−1·37	−0·52	68 5, 50·04	50·16	+0·12	−0·99	−0·87
14	37·28	W.	9 13 46·91	48·04	+1·13	−1·36	−0·23	71 41 43·57	46·74	+3·17	−4·33	−1·16
15	37·28	W.	10 7 52·01	53·09	+1·08	−1·34	−0·26	75 4 38·49	42·63	+4·14	−5·77	−1·63
16	37·29	W.	11 1 6·04	7·28	+1·24	−1·32	−0·08	79 18 51·35	55·36	+4·01	−6·90	−2·89
21	37·31	R.	15 29 48·44	49·66	+1·22	−1·44	−0·22	104 32 5·30	9·78	+4·48	−6·37	−1·89

Day, 1889	Correction to be subtracted from M.T. for change of Sidereal Time at Mean Noon since 1864.	Observer.	Observed R.A.	R.A. from Hansen's Tables for Uncorrected Mean Times.	Hansen minus Observed. Uncorrected.	Correction due to the Change in the Unit of Mean Time.	Hansen minus Observed. Corrected.	Observed N.P.D.	N.P.D. from Hansen's Tables for Uncorrected Mean Times.	Hansen minus Observed. Uncorrected.	Correction due to the Change in the Unit of Mean Time.	Hansen minus Observed. Corrected.
	s		h m s	s	s	s	s	° ′ ″	″	″	″	″
Feb. 22	37·31	R.	16 28 52·32	53·53	+1·21	-1·51	-0·30	108 18 13·51	17·96	+4·45	-4·85	-0·40
Mar. 11	37·38	W.	7 0 52·39	53·42	+1·03	-1·35	-0·32	67 45 6·50	6·76	+0·26	-0·30	-0·04
13	37·39	R.	8 49 43·60	44·62	+1·02	-1·37	-0·35	70 24 54·50	56·35	+1·85	-3·69	-1·84
15	37·40	W.	10 37 56·20	57·23	+1·03	-1·35	-0·32	77 20 56·39	61·89	+5·50	-6·60	-1·10
16	37·40	R.	11 31 24·38	25·43	+1·05	-1·34	-0·29	82 5 9·57	14·50	+4·93	-7·61	-2·68
21	37·42	F.B.	16 10 19·08	20·61	+1·53	-1·51	+0·02	107 28 39·86	45·27	+5·41	-5·48	-0·07
22	37·42	R.	17 11 50·30	51·65	+1·35	-1·56	-0·21	110 30 15·75	17·37	+1·62	-3·53	-1·91
Apr. 15	37·52	R.	13 48 29·42	30·41	+0·99	-1·42	-0·43	95 56 2·21	8·80	+6·59	-8·47	-1·88
May 6	37·60	R.	8 5 4·96	5·62	+0·66	-1·34	-0·68	68 16 54·71	54·45	-0·26	-2·29	-2·55
16	37·64	F.B.	17 24 26·51	28·12	+1·61	-1·67	-0·06	111 19 44·54	49·17	+4·63	-3·42	+1·21
21	37·66	R.	22 36 56·08	57·47	+1·39	-1·35	+0·04	103 11 55·80	47·82	-7·98	+6·73	-1·25
June 5	37·72	R.	10 22 42·44	42·96	+0·52	-1·29	-0·77	75 33 29·51	31·82	+2·31	-6·05	-3·74
13	37·76	F.B.	17 57 19·22	20·85	+1·63	-1·72	-0·09	112 17 12·39	13·87	+1·48	-2·26	-0·78
18	37·78	R.	23 10 57·44	58·78	+1·34	-1·34	0·00	100 21 11·08	3·85	-7·23	+7·41	+0·18
July 5	37·84	R.	12 35 55·62	56·22	+0·60	-1·28	-0·68	88 7 52·34	58·35	+6·01	-8·06	-2·05
6	37·85	F.B.	13 26 50·53	51·50	+0·97	-1·32	-0·35	93 29 25·97	31·06	+5·09	-8·25	-3·16
10	37·86	R.	17 22 3·20	4·44	+1·24	-1·68	-0·44	111 15 50·77	53·54	+2·77	-3·60	-0·83
16	37·89	R.	23 41 4·26	5·54	+1·28	-1·33	-0·05	97 28 50·38	43·28	-7·10	+7·91	+0·81

Day, 1889.	Correction to be subtracted from M.T. for change of Sidereal Time at Mean Noon since 1864.	Observer.	Observed R.A.	R.A. from Hansen's Tables for Uncorrected Mean Times. s	Hansen minus Observed. Uncorrected. s	Correction due to the Change in the Unit of Mean Time. s	Hansen minus Observed. Corrected. s	Observed N.P.D.	N.P.D. from Hansen's Tables for Uncorrected Mean Times. "	Hansen minus Observed. Uncorrected. "	Correction due to the Change in the Unit of Mean Time. "	Hansen minus Observed. Corrected. "
			h m s					° ′ ″				
July 18	37·90	R.	1 21 3·63	4·92	+1·29	−1·23	+0·06	87 5 46·20	37·96	−8·24	+7·74	−0·50
Aug. 5	37·97	F.B.	15 52 26·00	27·21	+1·21	−1·50	−0·29	106 37 36·03	41·07	+5·04	−6·20	−1·16
6	37·97	R.	16 53 29·67	30·61	+0·94	−1·60	−0·66	110 9 12·32	16·46	+4·13	−4·44	−0·31
7	37·98	F.B.	17 58 10·52	11·69	+1·17	−1·67	−0·50	112 20 52·76	55·18	+2·42	−2·14	+0·28
Sept. 6	38·10	R.	20 48 14·33	15·46	+1·13	−1·60	−0·47	110 23 47·30	42·89	−4·41	+4·38	−0·03
7	38·10	F.B.	21 49 41·74	42·95	+1·21	−1·52	−0·31	106 52 33·47	30·48	−2·99	+6·27	+3·28
9	38·11	W.	23 42 49·89	51·25	+1·36	−1·37	−0·01	97 7 57·95	50·01	−7·94	+8·26	+0·32
10	38·11	W.	0 35 13·52	14·87	+1·35	−1·32	+0·03	91 40 54·84	48·11	−6·73	+8·40	+1·67
12	38·12	F.B.	2 15 38·02	39·39	+1·37	−1·27	+0·10	81 13 36·42	30·55	−5·87	+7·44	+1·57
15	38·13	R.	4 46 29·19	30·20	+1·01	−1·32	−0·31	69 52 49·14	46·88	−2·26	+3·88	+1·62
16	38·14	F.B.	5 38 32·89	34·08	+1·19	−1·35	−0·16	67 51 35·74	35·88	+0·14	+2·32	+2·46
17	38·14	W.	6 31 28·49	29·62	+1·13	−1·36	−0·23	66 53 45·13	44·15	−0·98	+0·64	−0·34
Oct. 3	38·20	W.	20 26 35·69	36·96	+1·27	−1·59	−0·32	111 29 55·63	51·83	−3·80	+3·61	−0·19
4	38·21	R.	21 27 27·02	28·32	+1·30	−1·52	−0·22	108 28 40·62	34·94	−5·68	+5·57	−0·11
5	38·21	F.B.	22 25 17·54	19·03	+1·49	−1·44	+0·05	104 19 63·39	59·59	−3·80	+7·05	+3·25
7	38·22	F.B.	0 12 36·43	37·68	+1·25	−1·32	−0·07	94 3 63·22	57·90	−5·32	+8·41	+3·09
8	38·22	W.	1 3 22·52	23·77	+1·25	−1·29	−0·04	88 36 38·41	31·61	−6·80	+8·35	+1·55
9	38·23	R.	1 53 17·76	18·93	+1·17	−1·28	−0·11	83 19 39·57	32·61	−6·96	+7·88	+0·92

Day, 1889.	Correction to be subtracted from M.T. for change of Sidereal Time at Mean Noon since 1864.	Observer.	Observed R.A.	R.A. from Hansen's Tables for Uncorrected Mean Times.	Hansen *minus* Observed. Uncorrected.	Correction due to the Change in the Unit of Mean Time.	Hansen *minus* Observed. Corrected.	Observed N.P.D.	N.P.D. from Hansen's Tables for Uncorrected Mean Times.	Hansen *minus* Observed. Uncorrected.	Correction due to the Change in the Unit of Mean Time.	Hansen *minus* Observed. Corrected.
	s		h m s	s	s	s	s	° ′ ″	″	″	″	″
Oct. 13	38·24	R.	5 16 43·07	44·07	+1·00	−1·35	−0·35	68 19 19·23	18·08	−1·15	+3·03	+1·88
31	38·32	W.	21 9 46·52	47·80	+1·28	−1·54	−0·26	109 44 39·59	35·15	−4·44	+5·05	+0·61
Nov. 1	38·32	R.	22 7 53·65	54·94	+1·29	−1·45	−0·16	105 55 28·66	23·28	−5·38	+6·63	+1·25
2	38·32	F. B.	23 2 38·88	40·25	+1·37	−1·37	0·00	101 15 47·05	42·72	−4·33	+7·67	+3·34
4	38·33	W.	0 44 49·44	50·54	+1·10	−1·28	−0·18	90 42 9·39	3·17	−6·22	+8·37	+2·15
8	38·35	R.	4 3 34·69	35·87	+1·18	−1·32	−0·14	71 58 30·79	24·24	−6·55	+5·25	−1·30
12	38·36	W.	7 35 7·77	9·04	+1·27	−1·37	−0·10	66 42 57·57	57·25	−0·32	−1·42	−1·74
27	38·42	R.	20 49 35·38	36·51	+1·13	−1·61	−0·48	110 57 30·34	25·37	−4·97	+4·52	−0·45
28	38·43	F. B.	21 50 13·94	15·51	+1·57	−1·50	+0·07	107 24 29·02	23·91	−5·11	+6·32	+1·21
Dec. 2	38·44	W.	1 18 34·29	35·33	+1·04	−1·25	−0·21	87 8 48·78	42·72	−6·06	+8·19	+2·13
3	38·45	R.	2 6 52·64	53·67	+1·03	−1·25	−0·22	82 1 40·45	34·59	−5·86	+7·67	+1·81
10	38·49	W.	8 8 42·74	43·97	+1·23	−1·36	−0·13	67 25 3·58	5·85	+2·27	−2·48	−0·21
31	38·56	R.	2 40 22·55	23·44	+0·89	−1·26	−0·37	78 46 8·15	1·01	−7·14	+7·15	+0·01
Mean of Errors, without regard to sign	...	...	...	...	1·161	...	0·243	...	...	4·342	...	1·822
Mean Errors for Year	...	...	...	...	+1·161	...	−0·230	...	...	...	...	...

Observers : W., Mr. W. Wickham ; R., Mr. W. H. Robinson ; F. B., Mr. F. A. Bellamy.

<div align="center">

TABLE II.

Radcliffe Observations of the Moon, 1889.

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Errors of the Moon's Tabular Place in Longitude and Ecliptic Polar Distances, **Uncorrected** *and* **Corrected** *for the Change in the Unit of Mean Time introduced in the year* 1864.

Day, 1889.	Errors of Longitude (Hansen *minus* Observed).		Errors of E.N.P.D. (Hansen *minus* Observed).	
	Uncorrected.	**Corrected.**	**Uncorrected.**	**Corrected.**
Jan. 12	+ 15″·53	− 2″·75	− 0″·44	+ 0″·71
17	+ 19·68	+ 0·41	− 2·34	− 0·65
21	+ 16·90	− 3·99	− 1·17	− 0·49
22	+ 18·64	− 2·44	+ 0·95	+ 1·17
Feb. 7	+ 16·41	− 2·14	− 1·80	− 1·06
8	+ 13·81	− 4·57	− 2·51	− 1·43
9	+ 15·61	− 2·75	− 1·10	+ 0·23
11	+ 12·52	− 6·20	− 0·37	+ 1·31
12	+ 11·71	− 7·28	− 1·58	+ 0·18
14	+ 16·31	− 3·47	− 1·77	− 0·13
15	+ 16·13	− 4·11	− 1·63	− 1·20
16	+ 18·47	− 2·21	− 3·37	− 2·21
21	+ 18·33	− 3·57	+ 0·04	− 1·06
22	+ 17·74	− 4·29	+ 1·72	+ 0·27
March 11	+ 14·24	− 4·28	− 1·21	+ 0·40
13	+ 14·39	− 5·26	− 2·10	− 0·44
15	+ 16·09	− 4·77	− 0·55	+ 0·73
16	+ 16·32	− 5·03	− 1·66	− 0·75
21	+ 22·56	+ 0·27	+ 1·29	− 0·12
22	+ 19·05	− 3·10	+ 0·04	− 1·66
April 15	+ 16·21	− 6·69	+ 0·90	+ 0·53
May 6	+ 8·95	− 9·80	− 2·16	− 0·53
16	+ 22·75	− 0·76	+ 3·22	+ 1·26
21	+ 21·86	+ 1·01	+ 0·19	− 0·94
June 5	+ 7·89	− 11·81	− 0·59	+ 0·57
13	+ 22·61	− 1·25	+ 1·38	− 0·77
18	+ 21·10	− 0·07	+ 1·05	+ 0·17
July 5	+ 10·72	− 10·26	+ 2·00	+ 2·13
6	+ 15·45	− 6·07	− 0·69	− 0·98
10	+ 17·47	− 6·19	+ 1·61	− 0·42
16	+ 20·38	− 1·01	+ 1·07	+ 0·45
18	+ 21·10	+ 1·03	− 0·39	− 0·13

| Day, 1889. | | Errors of Longitude (Hansen *minus* Observed). | | Errors of E.N.P.D. (Hansen *minus* Observed). | |
		Uncorrected.	Corrected.	Uncorrected.	Corrected.
Aug.	5	+ 18″·12	− 4″·33	+ 1″·25	− 0″·25
	6	+ 13·63	− 9·27	+ 2·61	+ 0·74
	7	+ 16·23	− 6·93	+ 2·36	+ 0·30
Sept.	6	+ 16·49	− 6·36	− 0·01	− 1·79
	7	+ 17·38	− 5·30	+ 3·03	+ 1·59
	9	+ 21·82	− 0·26	+ 0·76	+ 0·23
	10	+ 21·41	− 0·25	+ 1·78	+ 1·72
	12	+ 21·18	+ 0·88	+ 1·19	+ 1·97
	15	+ 14·41	− 4·54	− 0·43	+ 1·05
	16	+ 16·49	− 2·31	+ 0·76	+ 2·37
	17	+ 15·51	− 3·19	− 1·85	− 0·16
Oct.	3	+ 18·14	− 4·30	+ 0·51	− 1·24
	4	+ 19·38	− 2·94	+ 0·42	− 1·09
	5	+ 21·59	− 0·52	+ 4·39	+ 3·29
	7	+ 19·42	− 2·21	+ 2·58	+ 2·43
	8	+ 19·96	− 1·15	+ 0·91	+ 1·20
	9	+ 18·83	− 1·86	− 0·38	+ 0·28
	13	+ 14·01	− 5·01	− 0·09	+ 1·50
	31	+ 18·61	− 3·69	+ 1·09	− 0·50
Nov.	1	+ 19·36	− 2·61	+ 1·52	+ 0·36
	2	+ 20·34	− 1·30	+ 3·79	+ 3·08
	4	+ 17·73	− 3·35	+ 0·74	+ 0·92
	8	+ 17·82	− 1·71	− 3·18	− 1·66
	12	+ 17·23	− 1·64	− 3·15	− 1·49
	27	+ 16·60	− 6·36	− 0·53	− 2·24
	28	+ 22·94	+ 0·54	+ 2·76	+ 1·48
Dec.	2	+ 16·77	− 3·73	+ 0·27	+ 0·78
	3	+ 16·44	− 3·70	− 0·30	+ 0·59
	10	+ 17·15	− 1·81	− 1·37	+ 0·17
	31	+ 14·69	− 5·19	− 2·79	− 1·65

Mean of Errors, without regard to sign ...17″·365   3″·646   1″·447   1″·019

Mean Errors for Year + 17″·365   − 3″·513

TABLE III.

Mean Excess over Observation of the Moon's Tabular Place in Longitude for the years 1847 to 1889, as Computed from Hansen's Tables.

Uncorrected *and* **Corrected** *on and after* 1864 *for the change in the Unit of Mean Time introduced in the year* 1864.

Year.	Errors of Longitude (Hansen *minus* Observed).	
	Uncorrected.	Corrected.
1847*	+ 1˙07	+ 1˙07
1848	+ 0˙20	+ 0˙20
1849	− 0˙47	− 0˙47
1850	− 0˙28	− 0˙28
1851	− 1˙29	− 1˙29
1852	− 0˙92	− 0˙92
1853	− 1˙63	− 1˙63
1854	− 1˙68	− 1˙68
1855	− 0˙87	− 0˙87
1856	− 0˙96	− 0˙96
1857	− 1˙86	− 1˙86
1858	− 1˙98	− 1˙98
1859	− 1˙80	− 1˙80
1860	− 2˙90	− 2˙90
1861	− 2˙19	− 2˙19
1862	− 2˙83	− 2˙83
1863	− 1˙61	− 1˙61
1864	+ 0˙12	− 0˙81
1865	+ 1˙27	− 0˙22
1866	+ 2˙14	− 0˙22
1867	+ 3˙48	+ 0˙36
1868	+ 4˙12	+ 0˙28
1869	+ 4˙28	− 0˙35
1870	+ 4˙83	− 0˙66
1871	+ 6˙96	+ 0˙44
1872	+ 7˙31	+ 0˙10
1873	+ 8˙24	+ 0˙20
1874	+ 9˙29	+ 0˙56
1875	+ 9˙87	+ 0˙36
1876	+ 9˙80	− 0˙50
1877	+ 9˙23	− 1˙90
1878	+ 8˙22	− 3˙60
1879	+ 9˙63	− 3˙12
1880†	+ 10˙89	− 2˙77
1881	+ 10˙51	− 4˙06
1882	+ 12˙68	− 2˙51
1883‡	+ 14˙71	− 1˙50
1884	+ 14˙65	− 1˙91
1885	+ 15˙20	− 1˙82
1886	+ 15˙34	− 2˙53
1887	+ 15˙70	− 3˙25
1888	+ 17˙68	− 2˙46
1889	+ 17˙37	− 3˙51

Radcliffe Observatory, Oxford :
    1890 *March* 11.

* 1847 to 1879, Greenwich observations.
† 1880 to 1882, Mean of Greenwich and Radcliffe.
‡ 1883 to 1889, Radcliffe observations.

A New Class of Binary Stars.   By Professor Edward C. Pickering.

A study of the photographic spectra of the stars undertaken as a memorial to Dr. Henry Draper has been in progress for several years at the Harvard College Observatory. This has led to the detection of certain binary stars whose components are too close to be separated by ordinary means. Suppose the two components of such a binary to have similar dimensions and identical spectra, and to revolve around each other in a circular orbit whose plane passes near the Sun. When the stars are in conjunction both are moving perpendicular to the line of sight, their spectra will be superposed, and it will be impossible to distinguish them from a single star. After making a quarter of a revolution or at elongation, however, one star will be approaching the observer rapidly, and all the lines in its spectrum will accordingly be moved slightly towards the blue end of the spectrum. The other star will be receding and its lines will be carried towards the red end. The two spectra will thus be separated so that every line will appear double. After another quarter of a revolution the motion will again be perpendicular to the line of sight and the lines will be single. At the next elongation the lines will be again double, and so that the star which was before approaching is now receding.

The occasional doubling of the K line in the spectrum of ζ *Ursæ Majoris* has already been announced. A careful study was made of this star last autumn. In all 113 photographs have been obtained on 80 nights. These seem to show that the lines became double at intervals of 52 days, corresponding to a period of revolution of 104 days. It now seems probable that the period should be reduced one half. Owing to the low altitude of the star the first photographs were often poor, but now that it rises higher during the night the law regulating the phenomenon will soon be determined. The spectrum is that of the first type in which the principal lines are those due to hydrogen, and are too broad to permit a slight separation to be detected in them. The other lines, except the K line, are very faint, and when double are seen with difficulty. The best photographs, however, show that several of these also are double, the separation being proportional to the wave-length of the line. The maximum separation of the K line somewhat exceeds 0·2 millionth of a millimetre, corresponding to a relative velocity of one star compared with the other of about a hundred miles a second.

A similar case has been discovered by Miss A. C. Maury, who is making a careful study of the spectra of the brighter stars. The star β *Aurigæ*, from 47 photographs on 30 nights, shows a distinct doubling of its lines at intervals of almost exactly two days, indicating a period of revolution of four days. The lines

are therefore alternately single and double on successive nights. The first indication of the doubling of the lines is that they become hazy, and the change is so rapid that it can sometimes be detected in successive photographs or in the two edges of the same spectrum. The width of the photographed spectrum, as explained elsewhere, is due to the gradual progress of the actual spectrum over the plate, in consequence of an intentional difference between the rate of the clock and the diurnal motion.

The type of spectrum resembles that of ζ *Ursæ Majoris*, but the hydrogen lines are finer, and the faint lines are better shown. About one hundred and fifty lines in all are visible when single, and in some photographs about a dozen of the more marked lines can be seen to be double, the others becoming hazy or invisible. The maximum separation of the K line is about 0·3 units, or three millimetres on the scale of the map of Ångström. The corresponding velocity is about one hundred and fifty miles per second. Hence it may be inferred that the distance of the two stars is about eight millions of miles, and that their total mass is 2·3 times that of the Sun. In other words, if two stars, each having a mass about one-fifth greater than that of the Sun, were placed eight millions of miles apart, and were made to revolve in a circular orbit, the observed phenomenon would be produced. The velocity here given is that of the component of the motion parallel to the line of sight. If the plane of the orbit does not pass through the Sun, the total velocity, radius, and masses will be proportionately increased.

The analytical conditions for determining the exact form of the orbit are comparatively simple. In the formulæ for elliptic motion it is only necessary to place the differential coefficient of the component of the motion parallel to the line of sight equal to the separation, and discuss its variation with the time. The results are reduced to absolute distances by the usual formula. (See *Proc. Amer. Acad.* xvi. 8.) If the orbit is circular the curve is that of sines. If elliptic, with the major axis directed towards the Sun, the maximum separation of the lines will not occur midway between the times at which the lines are single. If the major axis is perpendicular to the line of sight, the alternate separations will vary in amount, and the time required for any line to become single will be alternately long and short. This last case seems to be represented by ζ *Ursæ Majoris*, while the orbit of β *Aurigæ* seems to be nearly circular.

In β *Aurigæ* the more refrangible of the two components of the K line appears to be generally the more intense of the two, instead of becoming alternately brighter and fainter as might be expected if due to a real difference in the spectra of the two components. This is perhaps due to additional faint lines of somewhat shorter wave-length than K.

No satisfactory measurement has as yet been made of the parallax of β *Aurigæ*. We may, however, compare it with a *Aurigæ*, whose parallax, according to Dr. Elkin, is 0″·11. The

▲ ▲

proper motion of a *Aurigœ*, according to Auwers, is $0''\cdot43$, of β *Aurigœ* $0''\cdot07$. The ratio of the light is as $5\cdot7$ to 1. Accordingly, if a *Aurigœ* was removed to 6 times its present distance its proper motion would be about that of β *Aurigœ*; while if its distance was increased $2\cdot4$ times the brightness of he two stars would be about the same. This last quantity should probably be further increased owing to the greater intrinsic brightness of β *Aurigœ*. Estimates of distance based on these facts are of course uncertain, but they do not encourage us to anticipate a greater parallax for β *Aurigœ* than $0''\cdot05$. The maximum separation of the components would then be $0''\cdot004$. The maximum separation of the lines in the spectrum is about $20''$. Accordingly in this case the spectroscope may be said to make the apparent angle of separation about 5,000 times as great as it would be without the aid of the prism. If a binary star was found, one of whose components appeared to describe in four days an orbit of the size of the disc of *Jupiter*, we should regard it as a remarkable object. Yet this is the scale of the apparent motion of the components of the lines of the spectrum.

No binary star has hitherto been discovered having a period less than several years. The presence of dark bodies revolving in a few days around variable stars of the Algol type, however, indicates a phenomenon resembling that here described.

In view of the great velocity of these stars it might be thought that even a rare resisting medium would be sufficient to convert their energy rapidly into heat. Probably, however, such a medium would revolve with the stars, and its effect would therefore be small. There is no evidence of a change in brightness of β *Aurigœ* during the last two thousand years, as is shown by the following determinations of its light (*H. C. Annals*, xiv. 145): Ptolemy, A.D. 138, mag. $2\cdot1$; Sûfi, A.D. 964, mag. $2\cdot0$; W. Herschel, 1795, mag. $1\cdot9$; J. Herschel, 1835, $2\cdot3$; Harvard Photometry, 1880, mag. $2\cdot1$. The corresponding magnitudes for ζ *Ursœ Majoris* are $2\cdot1$, $2\cdot0$, $2\cdot2$, $2\cdot2$, and $2\cdot4$.

It is needless to add that the investigation is still in progress. Additional photographs are being taken, and a complete discussion will appear later. Similar changes are also suspected in several other stars. Photographs are accordingly taken of them at short intervals.

Harvard College Observatory:
   Cambridge U.S. 1890 *January* 8.

γ *Coronæ Australis.* By E. B. Powell.

The orbit for γ *Coronæ Australis* now submitted has been derived by the graphical method laid down by Sir John Herschel. The accordance between observation and calculation seems pretty fair, except in the case of the later distances; these imply that the distance is increasing, but there appears no doubt of its being on the decrease. By calculating the sectorial areas, the annual sector afforded by past observations does not differ much from ·087 of a square second; but the Windsor (Australia) measures give an area much in excess, indicating that the distances for 1887 and 1888 are very considerably greater than they should be. At the same time, as the agreement between observation and calculation is mainly for the north preceding side of the perspective ellipse, it is possible the apparent orbit does not possess *quite* sufficient width, but turns the southern end *somewhat* prematurely. If this be so, the projected centre of the orbit will be thrown more on the following side, and the position of the periastron will require to be a little advanced. Also, as the method pursued in arriving at the orbit draws some of the elements from α, the position-angle of the periastron, it may be found necessary to modify the dependent elements to a slight extent.

The period and the time of periastron passage were obtained from six equations of mean motion : the separate results were very fairly harmonious, the mean value of P not differing from the extremes by more than about half a year, and the mean value of T differing still less from its extremes.

The orbit agrees fairly well with the measures of Herschel, Jacob (excepting for the epoch 1850·46), and Schiaparelli. The greatest angular discrepancy, $+2°·1$, attaches to my own measure for 1870·1, which, as mentioned in my paper published in the *Monthly Notices*, No. 1, for November 1883, was the result of observations taken with an eyepiece of low power, my usual eyepiece having been lost. It seems there is greater difficulty generally in measuring the distance than in taking the angle of position of the star. This I experienced with my 5-foot equatoreal carrying a 4-inch object-glass. The smallness and the equality of the components enable an observer to lay a spider-line pretty accurately across their centres ; but, without a tolerably high power, it is far from easy to measure the distance satisfactorily. In my own case the distance was beyond my telescope, and I never did more than make an estimate of it. If I might be allowed, I would suggest that two or three observers possessing powerful telescopes should give attention just now to this binary. The comes is running in to its smaller minimum distance, $1''$ or a little more, and careful measures would enable a really excellent orbit to be deduced after the lapse of a few years.

Elements.

$a = 211°$ $λ = 153° 21' 19''$

$ɩ = 49° 17' 30''$

$γ = 48° 47' 23''$

$e = ·302872$

$P = 93·338$ years, mean annual motion $= 3° 51' 25''$ retrogr.de.

$T = 1885·192$

$a = 2''·034$

It would be premature at present to find variations of the position-angles for variations of the elements, and deduce corrections for the latter by means of the method of least squares ; I have therefore made no attempt in this direction.

Appended is a comparison of observed and calculated results, in which most of the measures taken are introduced.

Comparison of Observed and Calculated Results.

Observer.	Epoch 1800+.	$θ_o$	d_o	$θ_c$	d_c	$θ_o-θ_c$	d_o-d_c
Herschel	34·47	37·1	...	37·3	2·56	− ·2	...
„	35·55	36·8	...	35·7	...	+ 1·1	...
„	36·43	34·5	...	34·3	...	+ ·2	...
„	37·43	32·7	2·66	32·7	2·52	0	+ ·14*
Jacob	47·32	14·1	2·30	15·0	2·17	− ·9	+ ·13
„	50·46	5·9	2·29	7·8	2·02	− 1·9	+ ·27
„	51·54	4·5	2·26	5·1	1·96	− ·6	+ ·30
„	52·49	2·2	1·9	2·6	1·91	− ·4	− ·01
„	53·52	359·0	1·83	359·7	1·86	− ·7	− ·03
„	54·26	356·2	1·71	357·5	1·82	− 1·3	− ·11
„	56·44	349·4	1·67	350·5	1·71	− 1·1	− ·04
„	57·44	347·4	1·61	346·9	1·66	+ ·5	− ·05
„	58·20	343·4	1·53	344·1	1·62	− ·7	− ·09
Powell	59·72	338·1	1½ est.	338·0	1·55	+ ·1	...
„	61·69	328·8	...	329·4	...	− ·6	...
„	62·27	325·3	1½ est.	326·7	1·45	− 1·4	...
„	63·84	318·1	...	319·0	...	− ·9	...
„	70·19	286·9	...	284·8	...	+ 2·1	...
Schiaparelli	75·65	257·4	1·45	257·0	1·45	+ ·4	0
Howe	76·65	253·1	1·67	252·2	1·46	+ ·9	+ ·21
Schiaparelli	77·43	248·4	1·49	248·6	1·47	− ·2	+ ·02
Howe	78·49	242·9	1·47	243·7	1·48	− ·8	− ·01
Burnham	79·69	240·0	·87	238·2	1·47	+ 1·8	− ·60
Hargrave	80·67	232·4	1·32	233·7	1·47	− 1·3	− ·15
Wilson	83·62	217·7	1·62	219·4	1·40	− 1·7	+ ·22
Pollock	86·615	200·6	1·45	202·6	1·27	− 2·0	+ ·18
Tebbutt	87·728	196·2	1·68	195·3	1·21	+ ·9	+ ·47
„	88·67	188·7	1·77	188·6	1·16	+ ·1	+ ·61

* d_o for 37·21 years.

The following particulars afforded by the orbit may be noted. The greater maximum distance was $2''\cdot58$ nearly, for position equal to $41°$, and for epoch 1832 : the annual angular motion was then about $1°\cdot5$.   The smaller maximum distance was $1''\cdot48$, for position equal to $244°$ nearly, and epoch about $1878\cdot5$.   The greater minimum distance was $1''\cdot33$ approximately, for position equal to $297°$, and epoch about 1868.   The smaller minimum distance will be $1''\cdot05$ nearly, for position equal to $154°$, and epoch about $1892\cdot8$: the annual angular motion will then be nearly $9°$. Thus the greatest annual angular motion will be about six times the least.

Streatham Hill.

A Simple Method of obtaining an Approximate Solution of Kepler's Equation.   By Arthur A. Rambaut, M.A.

(*Communicated by Sir R. S. Ball, LL.D., F.R.S.*)

From time to time a good many suggestions have been made for obtaining approximate solutions of the equation

$$u - e \sin u = nt ;$$

but, although some of these are very useful when required in the case of one particular orbit, I know of no method, at once so simple and so easily applied to a number of orbits, as the following, which occurred to me when calculating the true anomalies for the binaries, given in Table II. of the following communication.

It depends on the principle that the abscissa of a prolate trochoid, generated by the rolling of a circle along a line parallel to the axis of x, is given by the equation

$$x = a\theta - d \sin \theta.$$

The construction will at once be seen from a description of the apparatus I made for myself, and by the aid of which I was able to obtain u for any orbit, to a quarter of a degree or so in about half a minute.

This degree of precision was, of course, quite sufficient for my purpose, but in various researches connected with double stars, such, for instance, as the comparison of the elements with the data or the construction of an ephemeris, a solution of this kind would, I think, furnish a very good first approximation.

In the figure, MN represents the edge of a straight ruler, glued to a sheet of millimetre paper, about 500^{mm} long and 250^{mm} broad, and which coincides with one of the lines on the paper.   PQ is a line drawn at right angles to the ruler, at a distance of about 130^{mm} from the left edge of the paper.   At a distance of 102^{mm} from the ruler is a line ROS parallel to it, and graduated to the right and left of PQ in degrees, on the scale of $314^{mm}\cdot159$ to $180°$.   ABD and A'B'D' represent two

positions of a piece of stout cardboard, carefully cut in the form of a semicircle of 200ᵐᵐ diameter, the radius CA being
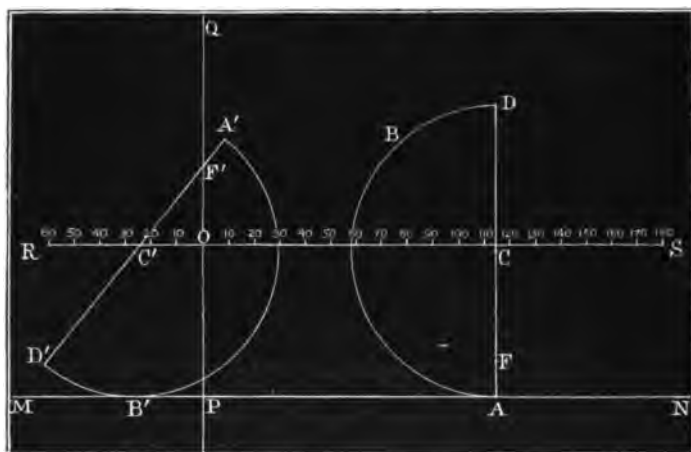
Kepler's Equation.

graduated in millimetres. A point F is taken on CA, so that

$$\frac{CF}{CA} = e.$$

To use the apparatus, all that is necessary is to set AD at right angles to RS (which is easily done by the lines on the paper) at a distance from PQ equal to the mean anomaly (nt), and to roll the semicircular card along the ruler until the point F lies on the line PQ. Then the distance OC' is equal to $u - nt$.

It only remains, therefore, to add OC', which is obtained in degrees directly from the scale RS, to nt in order to obtain u in degrees.

In the example illustrated in the figure, I have taken nt equal to twice the angular unit $= 114°·6$ and $e = 0·75$. By rolling the card I find

$$OC' = 26°·8 ;$$

whence

$$u = 114°·6 + 26°·8 = 141°·4.$$

On the Parallax of Double Stars. By Arthur A. Rambaut, M.A.

In a paper published in the *Proceedings of the Royal Irish Academy* (2nd ser., vol. iv., No. 6), I pointed out the relation connecting the parallax and the relative velocity of the compo-

nents of a double star with the period and angular elements of
its orbit, and discussed the possibility of determining the dis-
tance by means of spectroscopic observations of this velocity.

At the time my paper was read (May 1886), my examination
of the question seemed to point to the conclusion that the veloci-
ties to be expected were too small to be measured with any
degree of certainty, and although the photographic method even
then wore a very promising appearance, it seemed that, for some
time to come, at least, there was but little prospect of success in
this direction.

Since that date, however, the splendid progress made by
Professor Pickering and others in the art of photographing
stellar spectra has altered the whole aspect of the question, and
in particular the magnificent series of results, lately published in
the *Astronomische Nachrichten* by Professor Vogel and Dr.
Scheiner, seems to demonstrate the possibility of applying this
method with success to the determination of parallax.

It is in the hope of inducing astronomers who may be engaged
on this kind of observation, or who have the requisite instru-
ments at their disposal, to take up what, under present circum-
stances, appears to me a promising field of work that I venture
once more to direct attention to the subject.

In my paper before referred to (p. 666) I have shown
that if

ϕ denotes the angle between the tangent to the orbit and the major axis,

λ „ „ angle between the line of nodes and the major axis,

γ „ „ inclination ⎫

a „ „ semi-axis-major ⎬ of the orbit,

ϵ „ „ eccentricity ⎪

r „ „ radius vector ⎭

P „ „ period,

π „ „ parallax in secs. of arc ⎫ of the star,

V „ „ velocity in miles per sec. in the line of sight ⎬

l „ „ mean motion of the Earth in miles per second,

then

$$\pi V = \frac{la^2 \sqrt{1-\epsilon^2} \sin(\phi-\lambda) \sin \gamma}{Pr\sqrt{1-\epsilon^2 \cos^2\phi}}.$$

This equation gives us a relation between π and V depending
only on the period and angular elements of the orbit, by means
of which, if V has been determined by observation, π can be im-
mediately deduced.

In my previous paper I took unity as the critical value of πV
for this reason, that if πV is at any time equal to unity, we know
either that π is not less than one-tenth of a second of arc, or that
V is not less than ten miles per second—ten miles appearing to
me at that time as being about the limit of velocity which could
with certainty be detected.

A perusal of Professor Vogel's paper in Nos. 2896 and 2897 of the *Astronomische Nachrichten* shows, however, that this value may now be very much reduced. He there gives, amongst other results, ten different values for the motion of α *Aurigæ* in the line of sight, obtained on different nights, all lying between + 3·1 and + 4·0 German geographical miles, while his results for *Venus* agree within a tenth of a geographical mile with the calculated values. If, then, we assume that, where the components are fairly equal in brightness, a velocity of one English mile per second is not quite beyond the capabilities of the spectrographic m thod, we shall find that a number of double stars whose orbits have been determined are within measurable distance either by the trigonometrical or spectrographic method, so far, at least, as the values of π and V are concerned.

This being the case it seems to me desirable to reduce the formulæ to a more convenient shape, and to compute πV for some other stars not included in my previous paper.

I have shown (p. 667) that we may write

$$\pi V = \frac{lap' \sin (\phi - \lambda) \sin \gamma}{Pb},$$

where b is the semi-axis-minor and p' the perpendicular from the
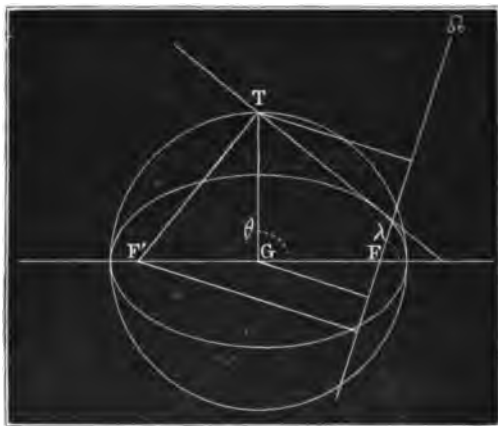
Parallax of Double Stars.

empty focus on the tangent to the orbit. Also $p' \sin (\phi - \lambda)$ is the orthogonal projection of p' on the line of nodes, and this (see figure) is equal to the sum of the projections of F'G and GT, where F'G is half the distance between the foci, and GT the line joining the foot of p' with the centre of the ellipse.

But the projection of F'G is equal to $ae \cos \lambda$, and that of GT is equal to $a \cos (\theta - \lambda)$, θ being the true anomaly, so that we have

$$\pi V = \frac{la^2 \sin \gamma}{Pb} [e \cos \lambda + \cos (\theta - \lambda)],$$

$$\text{or } \pi V = A + B \cos (\theta - \lambda)$$

$$\text{where } A = \frac{lae \sin \gamma \cos \lambda}{P \sqrt{1 - e^2}}$$

$$\text{and } B = \frac{la \sin \gamma}{P \sqrt{1 - e^2}}$$

$$\qquad \qquad \qquad \qquad \cdots \cdots \cdots \cdots \cdots \cdots (a)$$

A and B being constants depending only on the elements of the orbit.

If we wish to know at what time the value of πV reaches its maximum value for any particular binary pair we have to make

$$A + B \cos (\theta - \lambda) \text{ a maximum,}$$

or

$$\sin (\theta - \lambda) = 0.$$

Hence we see that, if we disregard the sign of V, the value of πV will be greatest when $\theta = \lambda$ or $\pi + \lambda$, or, as I showed otherwise in my previous paper, the relative velocity in the line of sight is a maximum when the body is passing through the line of nodes, and the first of equations (a) shows that its greatest value is $\pm A + B$, the upper or lower sign being taken according as λ is in the first or fourth, or in the second or third quadrants.

I may take this opportunity of saying that the method which computers of double-star orbits adopt of placing ☊ (on which the quadrant of λ depends) in all four quadrants is entirely misleading, as it is calculated to give the impression that there is some means of determining which is the ascending node from micrometric observations alone; whereas the fact is that we cannot from these data decide at which node the companion is receding from or approaching the Sun, nor is there even any convention as to which direction of motion should be implied by the term *ascending*. We can, of course, from micrometric measures fix the position of the *line* of nodes, but the longitude of the *ascending* node must always be doubtful to the extent of 180°, unless the spectroscope be employed and the resolved part of the velocity be sufficiently large to become sensible.

With regard to this point Villarceau, in his paper on double-star orbits, in the *Connaissance des Temps*, 1877, remarks:— "L'angle ☊ sera indéterminée à 180 degrés près. Cela doit être, puisque il est impossible de distinguer si le satellite en traversant l'un des nœuds s'écarte ou se rapproche de notre système solaire." Lower down he says: "Le signe de I" (the inclination of the orbit) "reste arbitraire. La longitude ☊, étant celle du nœud ascendant, est ambiguë, comme il vient d'être dit, et l'on peut toujours prendre I positif et compris entre 0 et 180 degrés. . . . L'hypothèse de I négatif change effectivement le nœud ascendant en nœud descendant." And, again, "La valeur de I . . . . restera affectée du double signe qu'on ne peut éviter."

Now, although this ambiguity is of no importance when we are concerned with only one particular binary system, and aim

only at predicting the distance and position of the pair for any given time, yet if we wish to draw general conclusions from the situations of a large number of groups, such, for the sake of illustration, as Mädler's conception of a "stellar equatorial plane," to which he supposes the planes of the double-star orbits to be approximately parallel, this ambiguity meets us at the very outset. If, for instance, we take the star *p Eridani*, and inquire how the plane of its orbit is situated with regard to the plane passing through *Procyon*, *Mira Ceti*, and the Sun, we shall find that we cannot tell whether it is approximately perpendicular or approximately parallel to it. Or if we compare the plane of the orbit of δ *Cygni* with that of the Earth's equator, we cannot determine whether it is inclined to it at an angle of 7 or of 82 degrees. The advantages, therefore, to be expected from spectroscopic, or rather spectrographic, observations of double stars for which πV is greater than 0·1, are

(1) An independent check on the parallax where this has been determined trigonometrically.

(2) A determination of the parallax where, owing to its smallness, the trigonometrical method fails.

(3) A determination of the sign of the inclination which will remove the ambiguity attaching to the situation of the orbit.

In Table I. below I give the elements of a number of orbits, and the values of A and B as computed from these elements. These quantities will enable us to compute the value of πV corresponding to any given time with the least possible labour, as it is only necessary to compute the value of θ for the given time, and to substitute the value thus found in the first of equations (a). In the last column of this table is given the greatest value to which πV can attain; and if it is required to ascertain at what epoch πV reaches its maximum value, it is only necessary to find the date corresponding to $\theta = \lambda$ or $\theta = \pi + \lambda$, according to the quadrant in which λ lies, as explained above. In Table II. will be found the values of πV for some of the most remarkable pairs, corresponding to the date 1891·0, and in those cases where the parallax has been determined I have added the value of V in the third column. It will be noticed that in the case of these stars, as might have been expected in consequence of their comparative nearness to us, the velocities are for the most part very small and such as direct eye-observations must fail to deal with. The success of Professor Vogel's method, however, and of the Henry Draper Memorial photographs, seems to hold out the hope that even velocities such as these may become sensible on the plates, and, in view of the very striking observations on ζ *Ursæ Majoris* lately published by Professor Pickering, it is not improbable that the highest velocities will be found, not in the wide and easy doubles, but in those close pairs such as δ *Equulei*, where, owing either to their remoteness or the smallness of the linear dimensions of their orbits, it is extremely difficult to divide the discs optically or to separate the two spectra on the photographic plate.

TABLE I.

Name of Star.	Magnitudes of Components.	Ω ° '	γ	λ ° '	e	a	P years.	T	Authority.	A	B	±A+B
η Cassiopeiæ	4, 7½	33 20	48 18	196 7	0·624	8″·639	+195·2	1902·0	Gruber	-0·469	0·782	1·251
36 Andromedæ	6, 7	57 54	41 39	142 19	·634	1·54	+349·1	1798·8	Doberck	-0·035	0·070	0·105
p Eridani	7, 7	81 42	44 40	327 15	·378	3·82	-117·5	1817·5	"	+0·145	0·456	0·601
40 Eridani (B.C.)	9, 11	146 20	76 20'	354 23	·136	5·99	-139·0	1863 9	Gore	+0·105	0·781	0·886
α Canis Majoris	1, 12½	45 27	58 37	136 39	·591	8·53	— 44	1889·4	Pritchard	-1·629	3788	5 417
Σ 1037	7, 7	156 58	68 17	273 27	·632	0·182	— 15·0	1827·7	Mädler	+0·010	0·269	0·279
α Geminorum	2½, 3½	31 58	42 5	291 1	·344	7·5375	-996·9	1750·3	Thiele	+0·014	0·100	0·114
ζ Cancri	5, 5½	81 33	15 32	109 44	·391	0·853′	— 60·3	1866·0	Seeliger	-0·010	0·076	0·086
Σ 3121	7½, 8	16 30	74 12	149 30	·26	[0·71]	+ 37·0	1842·8	Doberck	-0·079	0·353	0·432
ω Leonis	6, 7	148 46	64 5	121 4	·536	0·890	+110·8	1841·8	"	-0·044	0·158	0·202
φ Ursæ Maj. = OΣ.208	6, 7	105 18	57 57	72 7	·788	0·54	+115·4	1877·1	Casey	+0·029	0·119	0·148
γ Leonis	2, 3½	111 34	43 6	195 22	·733	1·98	+407·0	1741·0	Doberck	-0·066	0·090	0·156
ξ Ursæ Majoris	4, 5	100 13	56 40	125 0	·416	2·580	— 60·8	1814·5	Pritchard	-0·172	0·720	0·892
OΣ. 235	6, 7	96 17	60 13	129 55	·587	1·066	+ 94·4	1839·1	Doberck	-0·084	0·224	0·308
γ Virginis	3, 3	33 35	35 6	283 44	·896	3·97	-185·0	1836·7	Thiele	+0·109	0·513	0·622

TABLE II.

Values for 1891·0.

Name.	πV	V	π and Authority.
η Cassiopeiæ	−0·348	2·3	0˝·15 O.Σ.
36 Andromedæ	+0·034		
p Eridani	−0·305		
ι Canis Maj.	−5·326	13·4	0·39 Gill and Elkin.
Σ 1037	+0·151		
ι Geminorum	+0·112	0 6	0·20 Johnson.
ξ Ursæ Maj.	−0·294	7·4	0 04 Klinkerfues.
γ Virginis	+0 076		
α Centauri	+2·741	3 7	0·74 Gill and Elkin.
ξ Boötis	+0·372		
44 i Boötis	−0·082		
η Coronæ Bor.	−0·352		
51 ξ Libræ	+0 184 ·		
ζ Herculis	−0·325		
70 p Ophiuchi	+0 197	1 2	0·16 Krueger.
γ Coronæ Austr.	+0 698		
Σ 2173	−0·327		
O.Σ. 235	+0·076		
61 Cygni	−1·173	2·5	0·47 Ball.
,,	−0 285	0·7	,, ,,
ζ Aquarii	+0 041		

On some Celestial Photographs made with a large Portrait Lens at the Lick Observatory. By E. E. Barnard, M.A.

Professor Holden having secured for the Lick Observatory a very large portrait lens (maker, Willard, New York, 1859), I have taken advantage of the opportunity to make with it some experimental long-exposure negatives of the Milky Way, the great nebula of *Andromeda*, and the *Pleiades*. This lens, with the diaphragm removed, has an equivalent aperture of 5·9 inches, and a focal length of 31 inches.

The lens was mounted temporarily in a rough wooden box, and before beginning work the stellar focus was accurately determined by a series of exposures on *Polaris*, &c.

The camera was then strapped firmly upon the tube of the 6½-inch equatoreal, which, with a high power, was used as a following telescope. This instrument, having slow-motion rods in right ascension and declination at the eye-end, was specially

suited for controlling the motion of its clock, which with the
additional weight of the camera required careful and constant
attention.

Three negatives of different parts of the Milky Way were
made. The cluster M. 11 occupied the centre of one of these
plates; another plate covered the region $a=18^h$ 0^m, $\delta=-19°$;
while the third—in many respects the most remarkable of the
Milky Way plates—was in $a=17^h$ 56^m, $\delta=-28°$.

This last plate shows an object that I wish to call attention
to. For many years I have observed in my comet seeking a
most remarkable small inky black hole in a crowded part of the
Milky Way. This singular object, with one or two faint stars
in its following part, is in about $a=17^h$ 56^m, $\delta=-27°$ $50'$ (see
A. N. 2588, where I have called attention to it). I have not
seen this black hole mentioned anywhere. It is about 2′ in
diameter, slightly triangular, with a bright orange star on its
n. p. border and a beautiful little cluster following. There
are other dark holes and vast gaps near this, but nothing so
remarkable in the entire circuit of the Milky Way. On the night
of August 1 I made a negative of this region—the black hole
occupying the centre of the plate—with the intention of showing
the hole and the singular configuration of the Milky Way at that
point. An exposure of 3^h 7^m was given, a following star being
kept constantly bisected by cross wires in the eyepiece. Not
only is the black hole clearly shown in this negative, but the
entire cloudlike formation about it with myriads of stars are all
faithfully depicted. The exceeding beauty of a glass positive
from this plate is beyond description. The other two negatives
of the Milky Way are as fine as this, but the Milky Way itself
is not so grand.

A negative of the *Pleiades* on August 23, with an exposure
of 1^h 13^m, shows the *Merope* nebula quite conspicuously, the
small sharp projection of nebulosity from *Electra*, and some of the
nebulosity about *Maia* and *Alcyone*. The *Pleiades* at this time,
however, were very poorly placed for photographing.

Two negatives were made of the great nebula of *Andromeda*,
with exposures of 3^h 15^m and 4^h 18^m. Throughout these expo-
sures, as in the other cases, the eye was kept constantly fixed on
a star bisected by cross wires in the eyepiece, and the clock con-
trolled by the slow-motion rods. Both negatives clearly show
the dark spaces and the nebulous rings that were first shown to
exist by Mr. Roberts in his exquisite photographs of this nebula.
The rings of nebulosity are seen at a glance, though the image
on my negatives is on a small scale, the full extent of the nebula
covering one inch. I have tried to see these with both the 12-
inch and the 6½-inch, but without success, though the so-called
" canals " on the north side are clearly seen in both instruments.

In studying the distribution of the stars in space and the
structure of the Milky Way, it is clear that any legitimate means
of exaggerating peculiarities, or rather of bringing them out

more strikingly, is greatly to be desired. It would appear that the best way to do this is to photograph large areas of the sky so as to include enough material. If now we reduce this to a small scale, relations that would otherwise escape the eye are brought prominently forward. Acting upon this idea, I have made reduced copies of the above negatives. The result is striking. In the Milky Way pictures the cloudlike masses of stars stand out more boldly, and their forms are more definite than in the original. Reduced in this way, the picture of the region of the *Andromeda* nebula is singularly beautiful; and it shows in a most remarkable manner the peculiar structure of that part of the heavens. The intricate arrangements of the stars in rings and segments are thus shown as nothing else can show them.

Previous to these experiments, at Professor Holden's suggestion, I had attempted to photograph the Milky Way with a 1-inch (9 inches focus) Voigtländer lens, mounted on the 12-inch and the 6½-inch telescopes at different times. These exposures—running up to an hour and a half—showed absolutely no trace of the cloud-forms that are so striking to the eye. The plates were, however, literally sprinkled with stars, most of which were beyond the reach of the eye alone, and therefore much less bright than the Milky Way itself. The sensitive plate was not deceived by a quantity of light as the eye was; but as its action depends upon the intensity of the light, it had gone to work systematically to pick out the individual stellar points of the Milky Way. Of course we know if it had had time enough it would have finally begun the impression of the luminous groundwork. Nothing could show more beautifully the difference between intensity and quantity in the action of light upon the sensitive plate than these attempts to photograph the Milky Way.

With the Willard lens, which gave essentially thirty-six times as much light for the stars and three times that for the Milky Way, considered as a surface, three hours were required to show the cloud-forms.

Upon examining these plates, especially the one in 17^h 56^m $-28°$, it will be seen that we have here opened up for us a magnificent field of investigation. It is only necessary to mention the very great differences in the delineation of even the more conspicuous parts of the Milky Way, as shown on different star charts, to see that we have not the means in such charts to make anything like a comprehensive study of the Milky Way. Eyes differ so much, and astronomers, as a rule, are such very poor artists, that we may never expect to get anything like a fair delineation of the Milky Way by the human hand alone; and if we could, the human eye is too feeble to grasp the more important details, and the largest field of any telescope is too small to trace such large features with any accuracy. Observing and charting the stars does not aid us at all, for the true form of the Milky
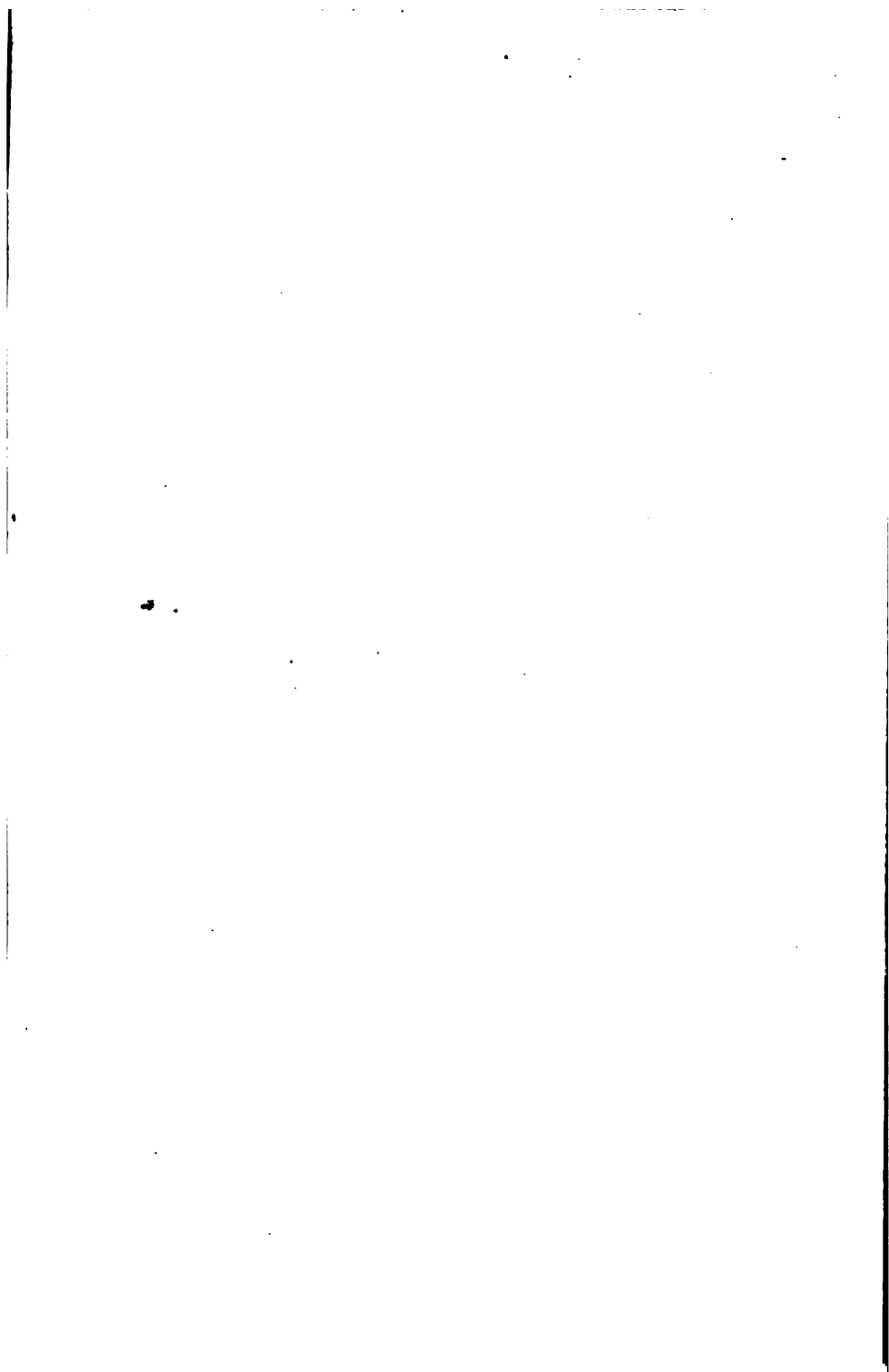
Fig. 1.   R.A. 17h. 56m. Decl.—28°, 1889, Aug. 1, 8h. 56m. to 12h. 3m. (1 in. = 1°·8).

Fig. 2.   M. 31, 1889, Aug. 26, 8h. 8m. to 12h. 25m. (1 in. = 1°·8).

Way does not depend on stars as bright as the ninth and tenth magnitude, but upon the millions of smaller stars, most of which are beyond the reach of any telescope. The photographic telescopes that are now being made—except, indeed, the Bruce telescope—will give us very little information about the structure of the Milky Way, as the field of view will be too small, and they will not show the cloud-forms.

What is wanted, therefore, is a photographic chart of the Milky Way made with a short-focus lens of the largest attainable aperture—one that will cover a field of at least one hundred square degrees—with an exposure time that will show the luminosity of the Milky Way. Such a chart can easily be made in one year's time, and must be of inestimable value. I am happy to make the first contribution to such a map.

I hope when the 6½-inch returns to the observatory to be able to resume the photography of the Milky Way.

The success of these long exposures suggests the possibility of extending the time of exposure through several successive nights, the same following star being used night after night, the plate remaining undisturbed, but carefully protected from light during the day.

I take pleasure, through the courtesy of Professor Holden, in presenting to the Royal Astronomical Society some glass positives of these negatives, and also an album with silver prints, both negative and positive, from the same.

Descriptions of the Photographs and Positives.

R.A. 18^h 0^m—$19°$. Album, pp. 4 and 5. 1889, July 28.— This is a remarkable region, but the exposure was too short to show it well, clouds having interfered. The adopted time of exposure is 1^h $17^m \pm$, with the aperture reduced to 4 inches.

The striking feature about this region is a series of vacancies that are fairly well shown in the print just below the dense mass of stars (p. 5). Another striking feature is the presence of a great many stars with ellipses, or partial ellipses, of small stars about them, the larger star apparently occupying the focus of the ellipse. One of the three large stars (p. 5) to the left (south) on the picture is a good example of this. The *Omega* nebula is shown on this print, to the right near the edge. In connection with this picture it is well to read Secchi's remarks on this same region, as given by Webb, *Celestial Objects,* p. 385, 4th edition.

Region near M. 11. Album, pp. 2 and 3. 1889, August 2, from 11^h 8^m to 13^h 53^m.—Here the cloudlike forms, partially resolved into stars, are finely shown. M. 11 is placed on the extreme N. edge of the connecting mass that extends between two vast clouds of stars.

R.A. 17^h 56^m, $\delta = -28°$. Album, pp. 1, 6, 7. 1889, August 1, 8^h 56^m to 12^h 3^m.—This remarkable picture shows the cloud-

forms like waves of spray. A dark curving lane runs from the lower left-hand portion of the picture, p. 6 (S.W.), and curves gracefully upwards to the place of *Jupiter.* It is singularly like the stem of a great leaf. At the middle of the picture it is seen to pass behind some of the clouds of stars and emerge beyond, showing us clearly which part of the Milky Way at that point is nearest to us. Imagination may aid one, but it looks as if the lines of the cloud-forms, and of the stars and vacancies, all run more or less concentric with this extensive lane. In the reduced glass positive, this lane and its connecting branches come out grandly (the glass positives should be examined with the light of a lamp through a white porcelain shade, or against the sky away from the region of the Sun). In this positive the masses of stars to the north-west of the middle resemble breaking spray. The black hole is seen slightly to the left of the centre, with the small cluster as a white spot close to the right of it. The planet *Jupiter,* at the top of the picture (not shown in the plate), is very large, from the excessive over-exposure, and mingles its light with that of the trifid nebula (Fig. 1, plate 3).

The Great Nebula of *Andromeda.* Album, pp. 8, 9, 10, 11. 1889, August 26, 8^h 8^m to 12^h 25^m.—I would call special attention to the *negative* print on p. 10, where the entire 8×10 negative is reduced to a scale of $5°·3$ to the inch. Above the preceding end of the nebula, and apparently connected with it, is a diffusion of light for some five degrees to the north-west, that looks very much like nebulosity. That this is real nebulosity I am somewhat doubtful. Yet the appearance is singularly real. It is possible that this is a reflection from the lenses, in some manner due to the very long exposure (4^h 18^m of sid. time). It has not been possible for me to verify it by repeating the exposure, but if it is true nebulosity, this plate will have been the first to show it (Fig. 2, plate 3).

It is needless to call attention to the remarkable structure of this part of the sky, as shown on this reduced picture, in contrast with that shown, say at 17^h 56^m—$28°$. The singular lanes of vacancies to the north-east of the nebula (p. 10) are so striking that the eye catches them at once. By carefully counting areas, I have estimated that there are 64,000 stars distinctly visible on the original 10×8 plates of this region.

It is unnecessary for me to go into any further description of the arrangements of the stars in these negatives, as that has already been thoroughly done by Professor Holden, in his communication on the subject. (See *Monthly Notices,* vol. l. p. 61.)

Mount Hamilton:
    1890 *January* 1.

Photograph of the Clusters 33 and 34 ♄ VI. Persei.
By Isaac Roberts.

The two well-known clusters in the sword-handle of *Perseus*, when seen on a photograph which has been exposed in a 20-inch reflector for three hours, present an appearance of grandeur that can only be fully realised by aid of the photographic method. The enlargement from the negative taken on January 13, 1890, is now before us, and any written description will convey only a very inadequate idea of it. The stars are densely crowded in the clusters, as well as in the surrounding and intervening spaces, and by looking at the photograph from a distance of about 18 inches from the eye, the festoon-like groupings of the stars are very striking; but at present I only attach to these combinations a fortuitous character, for we well know by experience that the eye readily sees patterns and groupings on any surface that is made up of a large number of small pieces in close contiguity. This general statement is not intended to exclude the possibility, or even probability, that numerous stellar systems will in time be found amongst the various star groups shown on photographs.

The clusters here referred to differ in character from those like the *Pleiades*, 13 *M. Herculis*, or 2 *M. Aquarii*, inasmuch as there is no trace of nebulosity shown in either of them; the component stars show on the negative as clear discs from the circumference to the centres of the two clusters, and this fact, when it is considered in connection with the nebular or the meteoritic hypotheses, suggests a relative progression in the evolution of some of the nebulæ and clusters which have already been photographically delineated and presented to the Society. For instance, the nebulæ in *Orion* and in the *Pleiades* have not yet assumed a symmetrical form like the nebulæ in *Andromeda*, in *Ursa Major*, and in the spiral nebula in *Canum Venaticorum*. These latter would therefore, on this hypothesis, be anterior in time, or have proceeded further in their development towards the formation of stellar systems, than the nebulæ in *Orion* or in the *Pleiades*.

The clusters 13 *M. Herculis*, 5 *M. Libræ*, and others, have still further than those of the *Andromeda* type developed into stellar systems, for the nebulosity remaining in them is faint and limited within the boundary of the clusters, and so approaches the period of total absorption. Again, we see the clusters in *Perseus*, now introduced, appearing to be quite free from nebulosity, and therefore, by this hypothesis, are anterior in time to any of the other nebulæ or clusters which have been referred to. We seem to be thus on the way, by the aid of photography, to an intelligible classification of some of the stages in the evolu-

tion of the universe, but of course we must proceed with caution and refrain from dogmatising. Our data are as yet limited, though of a striking character, and I shall at present be content with offering these suggestions, and continue to seek for further evidence, which in our dull climate is only to be obtained by much wearisome watching and promptness in grasping any opportunity.

Suspected Variability during Short Periods in certain Stars in Orion.
By Isaac Roberts.

The evidence of variability in some of the faint stars in *Orion* at present rests upon a photograph which I took with a dual exposure of the plate. The first exposure was of two hours' duration on January 29, and the second of $2\frac{1}{2}$ hours' duration on February 3, 1889, and on the enlarged copy of the photograph which I now present to the Society is shown the stars referred to, inclosed within a white ring, in order readily to distinguish them. The enlargement was made direct from the negative under the direction of Mr. Lockyer by his assistants at the Normal School of Science, South Kensington Museum. On examination of the dual stellar images on the photograph the eye immediately detects that ten of them have undergone considerable change in brightness or magnitude during the interval of five days which elapsed between the two exposures. In three of the ten stars, the brightness has increased to the extent of from one-fourth to one-third the measured diameter of the stellar photo-image, and one star appears on the second exposure where none is shown on the first exposure. Six of the ten stars have diminished in brightness during the interval to the extent of from one-fourth to four-tenths, the measured diameter of the photo-image. The following table gives the positions by Bond's chart and the measured photo-diameters of the ten stars :—

Table of the Positions by Bond's Chart and the Measured Diameters on the Photographic Negative of Variable Stars in the region of Theta Orionis.

No. of the Star on the Enlarged Photograph.	Approximate R.A. from θ¹ − Preceding + Following. (m s)	Approximate Declination from θ¹ − South + North. (′ ″)	Measured Photographic Diameters of the Ten Stars in parts of an inch. 1889, January 29.	1889, February 3.	Star Magnitude by Bond.	Deduced Variation in Magnitude from Columns 4 and 5 in this Table in parts of an inch. Increase.	Decrease.
1	− 0 38	− 42 20	0·00479	0·00629	7th	0·00150	...
2	− 0 20	− 23 15	680	406	14th	..	0·00274
3	− 0 5	− 23 15	499	613	12th	114	...
4	+ 0 32	− 26 15	634	477	14th	...	157
5	+ 1 44	− 0 30	712	427	15th	...	285
6	+ 2 17	+ 11 0	622	500	not on chart	...	122
7	− 0 25	+ 19 45	475	603	14th	128	...
8	+ 0 21	+ 17 15	535	351	not on chart	...	184
9	− 0 3	+ 37 45	no star	490	15th	490	...
10	− 0 9	+ 55 31	698	558	13th	...	140

I have with due care examined the film of the negative under the microscope in order to see if any defect or evidence of defective sensibility on parts of the film could be traced so as to account for the variability in the brightness of the stellar images, but I could not find any such evidence, and I would of course have repeated the photographic experiment if the state of the sky at any time during the past twelve months had permitted. Those who possess the necessary telescopic power may study by eye-observations the variability in these stars, and it is one of the functions of the photographic method to point out where eye-observations can with advantage be applied in search for special knowledge, and these ten stars are now indicated for that purpose.

Observations of the Variable Star S (10) *Sagittæ.*
By J. E. Gore.

The following are my observations of this short-period variable during the year 1889. They form a continuation of the observations given in *Monthly Notices* for March 1889.

The comparison stars are as before.

	Mag.
11 Sagittæ	5·8
DM. + 16°, 4086	7·0

Date.	Dublin M.T.	Mag.	Date.	Dublin M.T.	Mag.
	h m			h m	
1889 Jan. 1	7 30	5·8	1889 Oct. 15	10 12	6·13
May 24	10 10	5·7	16	7 35	6·16
June 3	10 40	6·28	17	10 27	6·4
July 15	10 38	6·24	22	11 15	5·75
29	10 0	5·8	23	7 55	5·7
30	10 10	5·8	24	6 40	6·0
31	9 35	5·9	26	6 35	6·34
Aug. 3	10 35	6·4	28	6 35	5·9
11	10 45	6·4	{ 30	6 37	5·75
20	9 55	6·45	{ 30	10 45	5·7
24	9 5	5·8	Nov. 5	7 35	5·9
30	8 30	6·2	16	6 50	5·8
31	11 15	5·7	19	9 30	6·15
Sept. 4	9 0	6·3	23	5 35	5·8
8	8 10	5·8	25	7 14	5·75
22	10 50	6·52	28	7 8	6·24
24	10 15	5·9	Dec. 5	7 29	6·13
25	8 30	5·7 (?)	11	7 58	5·7
Oct. 7	9 2	6·2	13	5 35	5·97
11	10 33	5·8	18	5 27	5·6
12	7 37	5·8	20	7 40	5·8
{ 13	6 40	5·8	22	6 10	6·08
{ 13	10 47	5·8	24	5 52	6·28

The observation of December 18 was near the maximum epoch No. 567, reckoning from an assumed maximum observed by me 1876 December 14.

* * *

Some Experiments relating to the Method of Obtaining the Coefficient of Absorption of the Wedge Photometer. By Edmund J. Spitta.

In a paper read before the Society in November 1887, on 'The Appearances presented by the Satellites of *Jupiter* during transit," * attention was called to the discordant figures obtained when photometrically comparing a point of light, such as, for example, is exhibited by the stars, with an object of sensible area such as *Jupiter*. For the past two years or more an extensive series of experiments with the wedge photometer has been in progress, with the object of ascertaining the cause or causes of such discordance ; but the subject has extended itself so much further than was anticipated, that it will be convenient to describe the results under three heads : (i) Those connected with the constant of absorption of the wedge photometer; (ii) the objections to employing such a form of photometer when dealing with objects of sensible area and the means devised to remedy the same ; and (iii) idiosyncrasies in the photoperceptive faculty of the eye when viewing different sized areas. The object of this communication is to set forth the experiments connected with the first division of the subject only—viz., those concerning the constant of absorption of the wedge photometer, with a suggestion for an improved method of obtaining the same.

In the course of some experiments made at an early stage of the inquiry, with light of varying but known intensity, a suspicion was raised that the results obtained by the method of wedge extinction were incorrect. This suspicion was entertained both with experiments made on points of light, and areas of equal diameters but of different degrees of illumination.

The readiest means for the complete examination of this question was evidently to conduct the experiments in such a manner as to ensure the addition of a known quantity of light to the point or area under examination. In my earliest experiments I arranged three gas burners in an equilateral triangle, any or all of which could be made to illuminate a small disc of cardboard equidistant from the three, and similarly situated with regard to the gas burners. The wedge was used without a telescope, though a telescope tube was found convenient both to carry the wedge and give the means of easy direction. The intensity of the illumination of the cardboard disc by each of the gas burners was first examined and made sensibly equal, and then the intensity of the illumination when increased by the

* *Monthly Notices*, vol. xlviii.

addition of each of the gas jets in turn was carefully determined by the method of wedge extinctions. Although it seemed certain from the precautions taken that when the combined light of the three gas jets was allowed to fall on the cardboard disc that this disc was illuminated by a light three times that which it exhibited when illuminated by only one, yet the indications of the photometer showed that the light of the disc was that which would be given by three and a half burners.

A repetition of the experiment under slightly different circumstances, and made with another apparatus, constructed, if possible, with still greater care, showed the same amount of error, and in the same direction. It was therefore determined to conduct the experiments on a larger scale—*i.e.*, with greater range of illuminating power, in which the errors of observation could not have so large a proportion to the final result. With this view, an argand burner was firmly fixed on a solid horizontal board provided with cross pieces to prevent warping. Around it at equal distances, but on another board placed at right angles to the first, was arranged a series of twelve 1-inch mirrors, each being provided with a ball-and-socket-joint to allow of the necessary accuracy of adjustment in the subsequent equalisation of the lights. The reflected light from every mirror passed through a separate hole in another board placed between the lamp and the disc, and every aperture was provided with an accurately fitting wooden shutter. The mirrors were entirely enclosed during the final measurements, the room being carefully darkened. The preliminary adjustment of the mirrors led to the rejection of four, because they reflected a smaller amount of light than the others, due to their position relatively to the lamp. One of the mirrors having been arbitrarily selected as the standard, the light from each of the others was made equal to it within the errors of observation. This will be seen from the following table, which gives the intensity of the illumination of the cardboard disc when the light from each of the mirrors was allowed to fall on it in succession. Calling the light—nominally converted for convenience into magnitude—of the standard mirror (1) L, that of each of the others proved to be:—

TABLE I.

No.	Mag.	No.	Mag.
2	L − ·042	6	L − ·014
3	L − ·092	7	L + ·092
4	L − ·075	8	L + ·014
5	L + ·075		

Before quitting the subject of adjustment, it may be remarked that, whatever difference may have previously existed in the reflective power of the mirrors, whether it arose from the silvering or from their position with respect to the lamp, is of no moment,

seeing that their light as reflected from the disc and viewed in the wedge photometer had been made as nearly equal as possible; and further, the light of the lamp is eliminated. All that is necessary was to ascertain that the light of the lamp did not vary during each series of observations, and this was readily effected by watching the light of the disc when illuminated by the mirror chosen as the standard

The experimental measures were then commenced, the mirrors being numbered from one to eight. The mean extinction of the standard was first obtained, shutter two then opened and the increase of light measured, shutter three next, and so on to the end of the series. On a subsequent night the whole of the observations were repeated, but this time the conjoint illumination from the first and eighth mirrors were compared with the standard to obtain the increase of light reflected by two mirrors, adding the value of the seventh to arrive at the increase afforded by three and so on, by which means it was thought that the possibly slight inequality of the illuminating power of the mirrors would be eliminated, the small discrepancies shown in Table 2 being attributed to the unavoidable errors of observation which they do not exceed.

TABLE II.

No.			
2	·76	·075	2·01
3	1·33	·05	3·40
4	1·85	·10	5·50
5	2·21	·04	7·66
6	2 44	·045	9·46
7	2·77	·08	12·83
8	3·03	·025	16·30

In column 1 is shown the number of mirrors employed, in other words the intensity which the wedge photometer must exhibit, if properly evaluated. Column 2 the difference in magnitude actually obtained by the wedge. Column 3, the probable error of this in magnitude, and column 4 the successive increase in light derived from the magnitude given in column 2.

It may be here stated that these figures were not hastily accepted, in fact not until every possible source of error that could be thought of, such as the effect of fatigue of the eye, sudden alterations in the pressure of the gas, the effect of using large or small discs, had been eliminated.

Two remarks, however, are naturally suggested by a consideration of this table. First that the increase in the amount of light as shown in column 4 does not appear to take place with the regularity which the addition of equal increments of light seems to demand But this difference is in a sense more apparent than real, arising from the necessary employment of a logarithm to convert the observed magnitudes into light-ratio. The point which is insisted on is that every addition of a unit of

light is accompanied by an observed result greater than the unit. The second remark is this ; that apparently, and as far as the table is concerned, a factor for the conversion of magnitude into light-ratio other than the conventional ·4 might be chosen which would satisfy the condition observed. Practically, if ·3 were taken, or if it were assumed that the light of each magnitude were double that of the one preceding, a tolerable agreement might be effected ; but this is impossible because in the determination of the constant of absorption of the wedge, the factor (·4) has been employed, owing to the original determinations having been made in light, and the differences in magnitude deduced by the convention.

A satisfactory explanation of the result arrived at in Table II. is not easy. The most plausible was that some error had been made in the evaluation of the wedge, or else that its absorbent properties had undergone some change after the numerous extinctions with which it had been employed in the *Jupiter* experiments. Accordingly resort was made to the method of evaluation as adopted by Professor Pritchard and explained by him in his Memoir on the wedge photometer,* and which is dependent upon the physical nature of polarised light. After acquiring a reasonable familiarity with the polarising apparatus, a determination of the coefficient of absorption over different portions of the wedge was effected and the result compared with that obtained by Mr. Plummer, who had kindly made the one used in the results given in Table II. It was found the two determinations were almost identical, the discordance not exceeding ·06 magnitude. This at once set aside the question of possible error in the evaluation, and proved that the wedge had not undergone any change from age and use. The only point to which it seemed that objection might yet be made in these experiments, was the employment of a disc which of necessity occupied some area on the wedge when undergoing extinction. The use of a point of light would vary the conditions somewhat under which the experiments had been made, and more nearly resemble the observations made on stars. By using an artificial star, which was effected by illuminating one of the small holes mentioned in the *Jupiter* experiments,† and controlling the light issuing through it by an Abney photometer, the following series of measures was obtained :—

TABLE III.

No.			
2	·92	·007	2·33
3	1 34	·035	3·43
4	1·63	·063	4 48
5	2 26	·021	8·05
6	2·36	·085	8 80
7	2·81	·028	13 31
8	3·03	·016	16·30

* *Memoirs R.A.S.*, vol. xlvii.
† *Monthly Notices*, vol. xlviii., and *The Observatory*, vol. x.

The arrangement of the figures in this table is precisely the same as in Table II.; and in estimating its accuracy or its apparent deviations from uniformity the remarks made on that table must be rigidly borne in mind. As a general rule, it will be seen that the resulting magnitudes of column 2 do not differ in the two tables by quantities much greater than those shown in the probable errors. The observations were thought to be easier for the brighter lights, or at least left a more favourable impression in the observer's mind, and in the case of the full brilliancy of eight lights the coincidence is exact. The interest is not lessened by the consideration of the fact that in the first set, reflections off a disc of sensible area were employed, but in the second, the augmentation in intensity was effected in a point of light.

At this juncture an opportunity occurred of testing another wedge by the polarising method, one made precisely after the model of that used by Professor Pritchard. The constant of absorption, carefully determined, gave a ratio of 1 16·40 instead of the real ratio of 1 : 8 which strikingly corresponded with the 1 : 16·30 obtained with the Clapham wedge, which was of a shorter and consequently steeper make, or one where a denser pigment had been employed in its manufacture.

As no solution of the difficulty presented itself, suspicion was attached to the accuracy of the sine law of Malus,[*] which underlies the polarising method adopted by Professor Pritchard, or rather, admitting the theoretical accuracy of the law, it did not seem impossible that the practical application of it might be attended with difficulties, and an unsuspected systematic error vitiate the results arrived at by its use. I proposed accordingly to test the practical application of the law by means of the Abney photometer; but the matter led to a protracted series of experiments, their entire discussion forming the subject of a paper communicated to the Royal Society by the kindness of Captain Abney, and read in June 1889, from which the substance of what follows is extracted. Before, however, giving a brief account of the experiments themselves, the precautions taken with them, and the results derived therefrom, it is necessary to hastily state the principle of the process employed by Professor Pritchard. If a Nicol's prism, capable of turning freely about its axis, be attached to a double-image prism, and two illuminated apertures (narrow rectangular slits are employed by Professor Pritchard) be viewed through this apparatus, there will be seen, as is well known, owing to the employment of the double-image prism, two images of each aperture, which can be successively made, by turning the Nicol through a definite angle, fainter and fainter till final disappearance of one pair of images supervenes. If the Nicol be furnished with the means of recording the angle through which it is turned, and (q) be the reading for the dis-

* Paris Académie des Sciences. *Mémoires présentées par divers Savants,* tome 2, 1811.

appearance of one of the images, and (q') be the reading for
another position of the Nicol, then the brilliancy of the object
(P) will be expressed by P $\sin^2 (q'-q)$, and P $\cos^2 (q'-q)$. Simi-
larly, the brilliancy of the second object or aperture Q will be
expressed by Q $\sin^2 (q'-q)$, and Q $\cos^2 (q'-q)$. Whence, making
the images derived from the *extraordinary* ray of P equal to that
produced by the *ordinary* ray of Q, the ratio of the light of P to
Q will be expressed by

$$\tan^2 (q'-q).$$

Practically it is convenient, owing to the difficulty in determin-
ing the precise angle at which the extinction of either ray occurs,
to observe equalities of brilliancy on each side of the zero, and this
is the method which Professor Pritchard has adopted for deter-
mining the absorptive power of a medium, by placing a certain
portion of his wedge behind the rectangular apertures already
mentioned, and measuring by the method indicated the ratios of
the light transmitted through those two portions, the distance
between which is carefully measured. It was originally intended
to employ in these experiments the method just described in
evaluating the constant of absorption of the wedge, but an
objection presented itself, for the two images not under examina-
tion were never of equal brilliancy whilst the observation for
equality in the other two was being effected. If small differ-
ences of intensity were being compared (as for instance in
evaluating the wedge) this was of no consequence, but when
illuminations of greatly different intensity were employed, the
disturbing effect was so distracting, that it was felt grave doubts
as to the accuracy of the observations might be justly entertained.
It was determined therefore to modify the arrangement by using
a single slit, Captain Abney's photometer being so arranged as
to diminish at will the illumination of either ray. The figures
obtained varied considerably, the observations being characterised
by a large observational error, but the ratio indicated by the
polarising apparatus *was always greater* than that shown by the
Abney photometer. Much larger prisms were then obtained,
and a more perfect apparatus constructed, the images being
focussed by a lens across a portion of the observatory on a screen,
the observer being surrounded by an improvised wall to secure
darkness during the subsequent equalisation of the lights. Still
the same result was manifest, the ratios exhibiting the same
peculiarity as in the earlier experiment, although be it noticed
the observational errors were much smaller. The assistance of
a friend well accustomed professionally to the equalisation of
lights was then sought, but the independent measures by him
again supported the previous experience. To find out the cause
or causes of this discrepancy between the ratios obtained and
those known to exist, became the subject of a most protracted
inquiry, but after eliminating all possible causes of error in the
apparatus, such as might occur from irregular illumination of

the slit, deviation in position of the lamp employed from night
to night, eccentricity of the Nicol, different absorptive power of
the two halves of the double-image prism employed, condition of
the lens used to focus the images on the screen, positions of the
prisms with respect to the line of collimation, and the possible
fluorescence of the material employed in the manufacture of the
screen, a suggestion due to Captain Abney, it was ultimately
found to be due to *polarised reflections from the inner surface of
the Nicol's prism* : rays which were found to utterly prevent the
correct equalisation of the images, either by augmenting the
angular reading in one position of the Nicol or detracting from
it in the other.   After some time, the effect of these reflections
was discovered to be completely eliminated by the use of a
diaphragm, placed between the eye and the Nicol, for after the
employment of such, the ratios came out reasonably accordant
with those known to exist, as the following table, extracted from
the paper in question, fully shows :—

<div align="center">

TABLE IV.

</div>

Known ratios.				Obtained by experiment.
1 to 2	...	...	...	1 to 2·14
3	...	...	...	3·02
4	...	...	...	3·84
5	...	...	...	4·97
6	...	...	...	5·80
12	...	...	...	11·97
18	...	...	...	17·11*

The crucial test, however, of the truth of the assertion that
the cause of the increase in the coefficient of absorption, as ob-
tained by Professor Pritchard's method, lay in the fact that the
polarised reflections from the internal surface of the Nicol were
not cut off by a suitably adjusted diaphragm, yet remained to be
proved.   For this purpose the rays issuing from the Nicol having
been focussed on the screen, and the precautions mentioned above
having been most carefully introduced, a fresh evaluation was
made of the wedge, when the resulting coefficient closely accorded
with that obtained by both the previous apparatus, as the follow-
ing table clearly exhibits :—

<div align="center">

TABLE V.

</div>

			Mag.
By the method of reflection from mirrors	...	...	·596
By the employment of Abney's photometer	...	...	·588
By the polarising method WITH diaphragm	...	...	·580
(By the polarising method WITHOUT diaphragm		...	·71)

* The cause of the falling off in this particular ratio is duly accounted
for.

It may seem to those who are not engaged in practical photo-
metry that the employment or non-employment of a diaphragm
is a very small matter, but that would be altogether to underrate
its importance. My real object in communicating the results of
these experiments to the Society is to point out the undesir-
ability of employing a method of evaluating which without great
precautions is likely to lead to uncertain results. Initially the
method, as hitherto practised, is open to a further objection, that
the difference of the intensities of light compared by means of
the polarising apparatus *must be small*; that is to say, the rect-
angular slits must be near together. In Professor Pritchard's
case, the distance between the slits was ·38 inch; and though
no doubt his caution and experience enabled him to reduce the
error of the determinations of the constant to a minimum, yet it
is nevertheless the fact that if the difference of wedge reading
be 3·8 inches, this error, however small, must be multiplied by
ten. An advantage of the polarising method, which must not be
lost sight of, is that it offers a very ready means of examining
the *uniformity* of a wedge, far more so, indeed, than any other
with which I am acquainted. If the intensities at any two places
on the wedge be equalised by a certain position of the Nicol, then
that same equalisation *must* be maintained for all other positions
of the wedge, the light of both slits being equally increased or
diminished as different portions of the wedge are presented to
view. But after considerable experience I am convinced a more
satisfactory and reliable plan to obtain the actual *constant of
absorption* consists in regulating the intensity of a point of light
by some such an arrangement as the photometer devised by
Captain Abney, and determining the point of extinction on the
wedge. In this way not only is the instrument evaluated by the
same method as it is used, viz., by a process of extinction, but
intensities differing in the ratio of 1 : 32 (or nearly four magni-
tudes) may easily be obtained, and the accumulation of error
referred to above effectually avoided.

I hope nothing I have said will be so misconstrued as to in-
duce the belief that I have any hesitation in accepting the results
derived by the aid of a wedge photometer. Far from it; I would
call attention particularly to the fact that the observations made
with such an instrument are *more* in accordance among them-
selves than is the case with those made with polarising apparatus.
Whether, as I am inclined to believe, and have explained above,
the effect of internal reflections, to some extent lawless but yet
so significant, is to enter into photometric observations made
with polarising apparatus (some positions of the Nicol requiring
the *very greatest* care to ensure their effectual elimination), I
must leave to be settled by those versed in the use of such
instruments; but the difference between the results of Dr. Wolff
and Professor Pickering * will be recalled by all. What I do
suggest, however, is that there is the possibility of introducing

* *Annals of Harvard Observatory*, vol. xiv.

a systematic error in observations made with a wedge where the error, arising from the coefficient of absorption, *is cumulative in its character*; but—and this, I submit, is a matter of great importance—this systematic error is of a character which can be removed, as I have pointed out, *not* by any comparison with observations of the same kind by other authorities, and the possible introduction thereby of a fresh source of error, but by a strictly independent and scientific investigation, with some form of photometer such as that devised by Captain Abney.

Ivy House, Clapham Common.

On a Method of Obtaining the Error of a Chronometer by Equal Altitudes of two Stars on Opposite Sides of Meridian. By A. Mostyn Field, Commander R.N.

The principle of this method depends upon the sidereal time of passing the meridian of a place, by an imaginary star, having the mean right ascension of the two stars selected, being compared with the time shown by a sidereal chronometer at that instant; the difference is its error on sidereal time. A mean solar chronometer can be used equally well. The sidereal time required is the mean of the right ascensions of the two selected stars. The chronometer time (either mean or sidereal) at that instant is the mean of the times at which the eastern and western stars had equal altitudes, with the " equation of equal altitudes " applied with its proper sign.

Equation of Equal Altitudes.

The rigorous expression, according to Chauvenet, is :—

$$\sin a = \cot \tfrac{1}{2} \text{ E.T. tan } d \text{ tan } \delta \cos a - \text{cosec } \tfrac{1}{2} \text{ E.T. tan } l \text{ tan } \delta,$$

where

$$a = \text{equation of equal altitudes} = \frac{h - h'}{2},$$

$$\tfrac{1}{2} \text{ E.T.} = \tfrac{1}{2} \text{ elapsed time} = \frac{h + h'}{2}.$$

d = declination at upper meridian passage.

$d - \delta$ = declination at observation E. of meridian.

$d + \delta$ = declination at observation W. of meridian.

$\delta = \tfrac{1}{2}$ difference of the declinations at the two times of observation.

h and h' = hour angles from noon at east and west observations respectively.

In the case of equal altitudes of two stars, one east and the other west of meridian, the above formula is strictly accurate whatever may be the difference in the declinations; the half elapsed time being found as follows :—

$$\tfrac{1}{2}\,\text{E.T.} = \frac{h + h'}{2},$$

$$= \frac{(R - S) + (S' - R')}{2},$$

$$= \frac{(R - R') + (S' - S)}{2}.$$

Where,

R and R′ = right ascensions of star E. and star W.,

S and S′ = sidereal time of observation of star E. and star W. respectively.

S′ − S, the difference of the sidereal times, may be taken as equal to the difference of times (as shown by a sidereal chronometer) of the observations of the two stars, the chronometer being of course corrected for rate.

If R′ > R, add 24^h to R.

If the western star be observed first, in which case

S > S′, then S and S′ are treated algebraically.

d = the mean of the declinations of the two stars.

δ = ½ difference of the declinations of the two stars.

In working the rigorous expression, an approximate value for a is first obtained, disregarding the term cos a, and then rework, using the value of a thus found.

Determination of Sign of " Equation of Equal Altitude."

The above figure is drawn to illustrate the ordinary cases which would occur in practice, but should the observer be in a high latitude, and select stars on the other side of the " six o'clock hour circle " than that shown above, the

following investigation of the sign of "equation of equal altitude" holds good also, and is unchanged.

When $\frac{1}{2}$ E. T. exceeds 6^h, the only changes of sign which occur are those in Chauvenet's formula.

In the accompanying figure, drawn on the plane of the horizon,

Let X and X' be positions of eastern star at 1st and 2nd observations,

Y and Y' be positions of western star at 1st and 2nd observations,

Υ and Υ' be positions of 1st p^t. of *Aries* at 1st and 2nd observations,

and let PX be less than PY.

Bisect angle XPY by hour-circle Pp.

Then, any imaginary star on Pp will have for right ascension the mean of the right ascension of X and Y.

Again, bisect angle X'PY' by hour-circle Pp'.

Then, any imaginary star on Pp' will have for right ascension the mean of the right ascension of X' and Y'.

Since the right ascensions of X and Y do not change *appreciably* in a few hours, we may assume that Pp and Pp' pass over the *same imaginary star*.

Bisect pPp' by the hour-circle Pq.

Then Pq can be shown to bisect XPY'.

That is qPQ or qQ is the "equation of equal altitude."

Now, if C and C' be the chronometer times (mean or sidereal) of observation,

$$\text{Mid. time by chronometer} = \frac{C'+C}{2} = \begin{array}{l}\text{time by chronometer, when the "imagin-}\\ \text{ary star" is on the hour-circle P}q.\end{array}$$

$$\therefore \left.\begin{array}{c}\text{time by chronometer when imaginary}\\ \text{star is on meridian PQ}\end{array}\right\} = \begin{array}{c}\text{time by chronometer when it is on}\\ \text{hour-circle P}q + \text{arc Q}q,\end{array}$$

$$= \frac{C'+C}{2} + \text{equation of equal altitudes.}$$

Similarly, when PX is greater than PY,

$$\left.\begin{array}{c}\text{Time by chronometer when imaginary}\\ \text{star is on meridian PQ}\end{array}\right\} = \frac{C'+C}{2} - \text{equation of equal altitudes.}$$

Method of Observation.

Select two bright stars, of nearly the same declination, not differing much from the latitude, but differing in R.A. by from 4^h to 8^h.

The mean R.A. is the sidereal time at which the imaginary star referred to above will pass the meridian; therefore the time at which it will be necessary to begin observing will be governed by this, and the observations of one star should be completed shortly before that time, in order to allow an interval to prepare for observing the other.

The sign of the "equation of equal altitudes" remains unaltered, whichever star is first observed.

C C

As a general rule, if the difference in right ascension is less than 6^h, the eastern star should be observed first; if it exceeds 6^h, then the western star; this is in order that the stars may be observed as favourably as possible, with respect to the prime vertical, but it will vary according to the latitude and declination. It will be noticed that if the observations are commenced with the eastern star, then they are, as a whole, taken further from the meridian than in the other case.

If the difference in R.A. exceeds 8^h, then there will probably be an interval between finishing the observations of one star and beginning those of the other, and part of the advantages of the method are lost; the same remark applies if the difference in R.A. is less than 4^h.

Having decided on which star to begin with, observe it continuously in the ordinary way, until the sidereal time is nearly equal to the mean R.A. of the two stars (the error of chronometer on sidereal time should be roughly known), then prepare to observe the other star, commencing at the same altitude as the last observation of the first star, and complete the series, which may be divided into sets, in the usual way.

Owing to the rapid change in "equation of equal altitudes" when there is a large difference in the declinations of the stars, it will be remarked that the "middle times" vary more rapidly than in the case of the Sun; and the rapidity of this change increases as the observations get further away from the sidereal time, at which the "imaginary star" passes the meridian.

If a mean solar chronometer be used, the chronometric interval (corrected for rate) must be turned into a sidereal interval, and the resulting "error of chronometer" will be the error on sidereal time at that particular instant, from which the error on mean time can be readily deduced.

Advantages.

1. The advantages and strength of the equal altitude method are retained, but without the inconvenience of having to wait some hours between the eastern and western observations.

2. There is less time for the chronometer to change its rate.

3. Atmospheric conditions for both eastern and western stars are more likely to be the same than after an interval of some hours.

4. Simplicity of computation; the only logarithms which change being those of cot and cosec ½ E. T.

5. On account of the shorter interval, there is a greater probability of being able to obtain the second half of the series.

Northampton :
    1890 *February* 7.

Further Note, with a Correction, on the Spectrum of the Sun-spot of June 1889. By the Rev. A. L. Cortie, S.J.

(Communicated by E. W. Maunder.)

In a former note on the spectrum of this important spot (*Monthly Notices*, vol. l., No. 2), the behaviour of the calcium lines in the region B to D was discussed. A comparison was also made with some calcium lines, in a list of bright lines, seen in a metallic prominence over the same spot, by Professor Spörer, of Potsdam, on June 28. A revised list was subsequently published by Professor Vogel (*Nature*, January 9, 1890), from which the calcium lines 6726·5, 6717·16, 6492·41 have been eliminated, and a line of iron (6677·6) and one of barium (6496·31) in the region under discussion have been substituted. A corresponding correction must, therefore, be made in the column headed "Prominence, June 28," of the table appended to my former note (*loc. cit.*, p. 65). Both these lines occur in Young's list of chromospheric lines. In the spot the iron line was widened 0·6 when observed on June 24, and the barium line, the widening of which is difficult to estimate on account of the surrounding telluric haze, was but slightly widened, if at all. The following remarks, in addition to those already published, contain the most noteworthy points with regard to the spectrum of the spot :—

1. The general absorption was dark, and the total number of lines observed as widened, or otherwise affected in the spot, was about two hundred and ten.

2. Of these the most widened lines included, besides calcium lines, lines of iron, titanium, and sodium. Barium and manganese were not much affected in the spot, nor was nickel, except the line between the D lines, which on June 20 was less dark over the spot, and on the 24th and 26th was not widened at all. The proportion of metallic lines among the most widened lines was greater than at the maximum Sun-spot epoch.

3. The most widened of all the metallic lines was the iron line 6148·28, which seemed to be surrounded by a broad and fuzzy band. Estimated widening, 5·0. This is one of Young's bright lines. Ångström draws it much darker than I see it.

4. Many faint lines were among the most widened lines. Among these were the lines 6039·4 (Fievez), 6053·28, and 6061·7 (F), lines which appear in this class, both in maximum and minimum spots. Also the doubles 6243·49, 42·60 ; and 6240·51, 39·42 ; which were either considerably widened on the more refrangible side, or displaced to the violet. The line 6305 (F) widened 3·0, was of the same breadth throughout over the spot, showing a steep-sided spot, and yet other lines were unmistakably of the usual spindle shape where widened.

C C 2

5. A faint line 6209·3 was seen only over the spot, widened 5·0. This line is in Angström's map, but neither in his nor Burton's catalogue; nor does it appear in the maps of Kirchhoff, Smyth, or Fievez. It was seen in the spectra of Sun-spots, always much widened, in 1884–5–6, at Stonyhurst. It was not seen in that of May 6, 1889. A careful search was made for the line on May 21, but it could not be detected. It reappears in the June spot.

6. A few faint lines were obliterated where they crossed the spot, none of them metallic lines.

7. The following table exhibits the results for the "basic" lines :—

Wave-length.	Elements.	Mean Widening.	Remarks.
*† 6064·70	Fe + Ti	0·5	
*† 6101·92	Ca + Li	0·7	
* † 6121·34	Ca + Co	0·8	
† 6154·41	Na + Fe	2·0	
6255·51	Fe + Ti	0·9	
* 6346·34	Ru + Ir	0·3	
*† 6392·87	Fe + Sb	0·6	
† 6407·38	Fe + Sr	0·5	
† 6438·35	Ca + Cd	1·2	
† 6449·29	Ca + Ba	1·2	
*† 6461·98	Fe + Ca	1·2	Bright in prominence June 28.

On the Proper Motion of Groombridge 1830.
By W. T. Lynn, B.A.

It is now nearly fifty years since the large proper motion of *Groombridge* 1830 was detected by Argelander. In the *Monthly Notices* for June 1870 (vol. xxx., p. 203), I put together the results of the observations which had been obtained at the Royal Observatory, Greenwich, of this star, taking the places from the successive great catalogues from the twelve-year (epoch 1845) to the second seven-year (epoch 1864), which was then passing through the press under my own immediate superintendence. Perhaps it may be acceptable if I now complete this by adding the results from the catalogues (the nine-year for 1872, and the ten-year for 1880), which have been since published. It will be noticed that no fewer than 90 observations in R.A. and 100 in N.P.D. have been made at Greenwich of this remarkable

* Bright in chromosphere, Young.
† Resolved either by Liveing and Dewar, or by Fievez.

star, and that the interval between the adopted epochs of the first and last of all these catalogues amounts to 35 years.

Positions of Groombridge 1830.

Epoch.	R.A.	No. of Obs.	N.P.D.	No. of Obs.	Authority.
	h m s		° ′ ″		
1845	11 44 1·53	13	51 10 10·90	10	12-year catalogue.
1850	11 44 19·04	17	51 12 20·04	19	6-year catalogue.
1860	11 44 53·91	18	51 16 37·44	18*	7-year catalogue (1860).
1864	11 45 7·83	8	51 18 21·22	8	7-year catalogue (1864).
1872	11 45 35·68	26	51 21 47·05	31	9-year catalogue.
1880	11 46 3·53	8	51 25 13·92	14	10-year catalogue.

From these we obtain the following mean annual variations for the years comprised between each successive epoch :—

Years.	Ann. Var. in R.A.	Ann. Var. in N.P.D.
	s	″
1845–1850	+ 3·502	+ 25·85
1850–1860	3·487	25·74
1860–1864	3·480	25·94
1864–1872	3·481	25·73
1872–1880	+ 3·481	+ 25·86

Deducting from these the annual precession, amounting to $+ 3^s \cdot 144$ (diminishing to $3^s \cdot 138$) in R.A., and $+ 20'' \cdot 01$ in N.P.D., the following will be the values of the proper motion deducible from these observations :—

Years.	Proper Motion in R.A.	Proper Motion in N.P.D.
	s	″
1845–1850	+ 0·358	+ 5·82
1850–1860	0·344	5·73
1860–1864	0·338	5·93
1864–1872	0·341	5·72
1872–1880	+ 0·343	+ 5·85

Blackheath :
    1890 *January* 29.

    * By a misprint this appears as 8 in my former paper.

Observations of Comet 1888 (*Barnard, Sept. 2*), made at Sydney Observatory with the 11½-inch Equatoreal and Filar Micrometer.

(Communicated by H. C. Russell, B.A., F.R.S., Government Astronomer.)

Date.	Sydney M.T.	Star.	Comp.	Comet − Star ΔR.A.	Comet − Star ΔN.P.D.	Comet's Apparent R.A.	Comet's Apparent N.P.D.	Log. $p\Delta$ for R.A.	Log. $p\Delta$ for N.P.D.
1889.	h m s			m s	″	h m s	° ′ ″		
Aug. 13	7 20 43	1	10	+4 37·24	− 6 19·7	19 19 16·47	95 30 55·0	9·478n	0·635
19	8 0·49	2	10	−4 41·90	+10 56·8	19 4 45·77	96 25 22·1	9·184n	0·612

Mean Places of the Comparison Stars for 1889·0.

Star.	R.A. 1889·0.	Reduction.	N.P.D. 1889·0.	Reduction.	Authority.
	h. m s	s	° ′ ″	″	
1	19 14 37·13	+2·10	95 37 23·3	−8·6	Radcliffe 2nd Cat. 1844, Yarnall 8255.
2	19 9 25·62	+2·05	96 14 33·9	−8·6	Lalande 36737.

The foregoing late observations may perhaps be useful in checking the orbit of the comet; they were made by Mr. J. A. Pollock.

Sydney Observatory :
1889 December 31.-

Observations of Phenomena of Jupiter's Satellites at Windsor, New South Wales, in the Year 1889. By John Tebbutt.

Day of Obs.	Satellite	Phenomenon	Phase.	Aperture of Telescope.	Mag. Power.	Greenwich Mean Time of Observation. h m s		Mean Time of Nautical Almanac. h m s
1889.								
May 9	I.	Ecl. D.	Last seen	8-inch	75	1 0 31		1 0 2
21	III.	,,	Began to fade	,,	,,	5 52 52	}	5 57 30
21	III.	,,	Last seen	,,	,,	5 59 58		
June 1	I.	Tr. Ingr.	Ext. contact	,,	130	22 47 8	}	22 49
1	I.	,,	Bisection	,,	,,	22 49 5		
1	I.	,,	Int. contact	,,	,,	22 51 34		
2	I.	Tr. Egr.	Int. contact	,,	,,	0 59 53	}	1 6
2	I.	,,	Bisection	,,	,,	1 1 38		
2	I.	,,	Ext. contact	,,	,,	1 4 22		
2	I.	Occ. R.	Last contact	4½-inch	90	22 24 17	}	22 24
2	I.	,,	Last contact	,,	,,	22 26 17		
9	I.	Ecl. D.	Began to fade	,,	,,	21 29 18	}	21 33 4
9	I.	,,	Last seen	,,	,,	21 33 26		

Day of Obs.	Satellite.	Phenomenon.	Phase.	Aperture of Telescope.	Mag. Power.	Greenwich Mean Time of Observation. h m s		Mean Time of Nautical Almanac. h m s
1889.								
June 10	I.	Occ. R.	Last contact	8-inch	130	0 9 26		0 8
10	I.	Tr. Egr.	Int. contact	4½-inch	90	21 9 35	⎫	
10	I.	,,	Bisection	,,	,,	21 12 20	⎬	21 16
10	I.	,,	Ext. contact	,,	,,	21 14 59	⎭	
12	II.	Tr. Ingr.	Ext. contact	8-inch	110	21 36 38	⎫	
12	II.	,,	Bisection	,,	,,	21 39 7	⎬	21 40
12	II.	,,	Int. contact	,,	,,	21 42 22	⎭	
13	II.	Tr. Egr.	Int. contact	,,	75	0 12 22	⎫	
13	II.	,,	Bisection	,,	,,	0 16 41	⎬	0 19
13	II.	,,	Ext. contact	,,	,,	0 20 10	⎭	
16	I.	Ecl. D.	Began to fade	,,	,,	23 24 44	⎫	
16	I.	,,	Last seen	,,	,,	23 27 44	⎭	23 27 18
17	I.	Tr. Egr.	Int. contact	,,	,,	22 52 53	⎫	
17	I.	,,	Bisection	,,	,,	22 55 47	⎬	22 59
17	I.	,,	Ext. contact	,,	,,	22 59 32	⎭	
21	IV.	Tr. Ingr.	Ext. contact	,,	110	0 19 59		0 46

Day of Obs.	Satellite.	Phenomenon.	Phase.	Aperture of Telescope.	Mag. Power.	Greenwich Mean Time of Observation. h m s	Mean Time of Nautical Almanac. h m s
1889.							
June 21	IV.	Tr. Egr.	Ext. contact	8-inch	110	1 7 51	1 0
24	I.	Tr. Ingr.	Ext. contact	„	70	22 22 58	22 26
24	I.	„	Bisection	„	„	22 25 33	
24	I.	„	Int. contact	„	„	22 29 27	
25	I.	Occ. R.	Last contact	„	„	22 6 30	
28	II.	Occ. D.	First contact	4½-inch	90	20 11 1	20 15
28	II.	„	Bisection	„	„	20 14 20	
28	II.	„	Last seen	„	„	20 16 0	
28	II.	Ecl. R.	First seen	8-inch	70	23 5 29	23 5 17
28	II.	„	Full brightness	„	„	23 7 26	
July 6	III.	Tr. Egr.	Int. contact	„	„	21 2 42	21 13
6	III.	„	Bisection	„	„	21 6 57	
6	III.	„	Ext. contact	„	„	21 13 11	
9	I.	Occ. D.	First contact	„	„	23 11 8	23 14
9	I.	„	Bisection	„	„	23 13 47	
9	I.	„	Last seen	„	„	23 15 47	

Day of Obs.	Satellite.	Phenomenon.	Phase.	Aperture of Telescope.	Mag. Power.	Greenwich Mean Time of Observation.	Mean Time of Nautical Almanac.
						h m s	h m s
1889.							
July 13	III.	Tr. Ingr.	Ext. contact	8-inch	70	21 32 52	21 39
13	III.	,,	Bisection	,,	,,	21 38 21	
13	III.	,,	Int. contact	,,	,,	21 44 10	
14	III.	Tr. Egr.	Int. contact	,,	,,	0 19 4	0 32
14	III.	,,	Bisection	,,	,,	0 25 3	
14	III.	,,	Ext. contact	,,	,,	0 31 47	
Sept. 5	III.	Ecl. R.	First seen	,,	75	20 37 30	20 39 55
5	III.	,,	Full brightness	,,	,,	20 43 15	
12	III.	Ecl. D.	Last seen	,,	,,	21 44 18	21 43 4
25	I.	Ecl. R.	First seen	,,	,,	22 55 31	22 55 41
25	I.	,,	Full brightness	,,	,,	22 58 11	
30	II.	Tr. Ingr.	Ext. contact	,,	110	22 44 40	22 39
30	II.	,,	Bisection	,,	,,	22 46 5	
30	II.	,,	Int. contact	,,	,,	22 48 9	

Remarks.

May 9.—Unsatisfactory observation through thin cloud. Planet free from cloud 20 seconds subsequently, but satellite not then visible.

May 21.—Sky beautifully clear, but Moon in last quarter. Slight tremor of images at moment of final disappearance.

June 1, 2.—Fair definition at ingress, and better at egress. Planet low, and boiling at occultation phase.

June 9.—Images steady and well defined. Sky clear and observation good.

June 10.—Definition pretty good at the occultation phase and at the first two phases of the transit egress. Image very much disturbed at the external contact.

June 12, 13.—Definition bad and observations unsatisfactory.

June 16, 17.—Sky beautifully clear. Images steady and well defined at the eclipse, but the Moon had risen. Images rather tremulous at transit egress.

June 21.—Good definition, but observation very difficult. No internal contact occurred.

June 24.—Steadiness and definition satisfactory.

June 25.—Good definition, but observed time rather late. The reappearance from eclipse could not be observed.

June 28.—Sky beautifully clear. Planet low and badly defined at the occultation. Definition good for the eclipse.

July 6.—Images steady and well defined, but power not sufficiently high for satisfactory observation.

July 9.—Images steady and well defined. Good observation.

July 13, 14.—Definitions unusually good at both ingress and egress. The satellite crossed a portion of the planet's disc as a dark spot.

Sept. 5.—Sky clear about the planet. The first recorded time is probably 10 or 15 seconds late.

Sept. 12.—Sky beautifully clear, and definition good.

Sept. 25.—Sky clear, but images tremulous and badly defined.

Sept. 30.—Images steady and definition good. There is a considerable discrepancy between the computed and observed times.

Note.—No occulting bar has been employed in the eclipse observations. The times given in the first and seventh columns are the Windsor mean times of observation diminished by $10^h 3^m 20 \cdot 5$ and entered to the nearest second.

Windsor, N.S. Wales:
   1889 December 27.

Ephemeris for Physical Observations

Greenwich Noon	Angle of Position of ♃'s Axis.		Latitude of Earth above ♃'s Equator.	Sun	Annual Parallax.	Longitude of ♃'s Central Meridian.		Corr. for Phase.
	P	L−O.	B	R	A−L.	(877°·90) L	(870°·27) II.	
1890	°	°	°	°		°	°	°
Mar. 23	343·946	170·226	−0·780	−1·006	− 9·410	229·38	130·72	+0·39
28	343·646	171·081	·739	0·985	9·839	298·37	161·56	·42
Apr. 2	343·366	171·890	·699	·963	10·221	7·42	192·46	·45
7	343·106	172·650	·660	·941	10·554	76·53	223·42	·48
12	342·867	173·358	·622	·919	10·835	145·71	254·44	·51
17	342·649	174·010	·585	·898	11·060	214·95	285·53	·53
22	342·453	174·602	·549	·876	11·225	284·26	316·68	·55
27	342·280	175·131	·515	·854	11·326	353·63	347·90	·56
May 2	342·129	175·595	−0·483	−0·832	− 11·361	63·07	19·19	+0·56
7	342·001	175·990	·453	·810	11·327	132·57	50·54	·56
12	341·897	176·313	·424	·787	11·221	202·15	81·96	·55
17	341·817	176·561	·397	·765	11·040	271·80	113·45	·53
22	341·762	176·733	·373	·743	10·782	341·51	145·02	·51
27	341·731	176·826	·352	·720	10·445	51·29	176·65	·48
June 1	341·724	176·840	−0·333	−0·698	− 10·029	121·14	208·34	+0·44
6	341·743	176·774	·316	·675	9·534	191·05	240·09	·40
11	341·786	176·630	·302	·653	8·959	261·02	271·91	·35
16	341·854	176·408	·291	·630	8·305	331·05	303·79	·30
21	341·946	176·111	·283	·608	7·577	41·12	335·71	·25
26	342·061	175·743	·277	·585	6·778	111·24	7·68	·20
July 1	342·198	175·310	−0·274	−0·562	− 5·914	181·40	39·69	+0·15
6	342·355	174·818	·274	·559	4·990	251·59	71·72	·11
11	342·531	174·275	·277	·517	4·014	321·80	103·78	·07
16	342·723	173·689	·281	·494	2·996	32·01	135·84	·04
21	342·927	173·071	·288	·471	1·945	102·22	167·90	+0·02
26	343·142	172·432	·297	·448	− 0·873	172·41	199·94	·00
31	343·362	171·784	·307	·425	+ 0·210	242·58	231·95	·00
Aug. 5	343·584	171·137	−0·318	−0·402	+ 1·291	312·71	263·93	− 0·01
10	343·804	170·504	·331	·379	2·357	22·78	295·86	·02
15	344·018	169·896	·344	·356	3·399	92·79	327·72	·05
20	344·221	169·324	·357	·332	4·406	162·73	359·51	·08
25	344·409	168·798	·370	·309	5·366	232·59	31·22	·13
30	344·579	168·328	·382	·286	6·272	302·37	62·85	·17
Sept. 4	344·727	167·920	−0·394	−0·263	+ 7·116	12·05	94·38	− 0·22

of Jupiter, 1890.   By A. Marth.

Greenwich Noon.	Apparent Diam. Equat.	Polar.	Difference of limbs in A.R.	in Decl.	Defect of illumination. Equat.	in A.R.	in Decl.	d	w
1890.	$''$	$''$	s	$''$	$''$	s	$''$	°	°
Mar. 23	34·92	32·70	2·454	32·87	0·23	0·016	0·02	9·41	271·55
28	35·35	33·11	2·481	33·29	·26	·017	·02	9·84	·60
Apr. 2	35·82	33·54	2·510	33·73	·28	·019	·02	10·22	·65
7	36·31	34·00	2·541	34·20	·31	·020	·02	10·56	·70
12	36·82	34·48	2·575	34·69	·33	·022	·02	10·84	·74
17	37·37	34·99	2·610	35·21	·35	·023	·03	11·06	·79
22	37·94	35·52	2·647	35·75	·36	·024	·03	11·23	·85
27	38·53	36·07	2·686	36·31	·37	·024	·03	11·33	·90
May 2	39·14	36·65	2·727	36·89	0·38	0·025	0·03	11·37	·94
7	39·77	37·24	2·769	37·49	·39	·025	·03	11·33	271·99
12	40·42	37·84	2·813	38·10	·39	·025	·03	11·23	272·04
17	41·08	38·46	2·858	38·72	·38	·025	·03	11·05	·09
22	41·74	39·08	2·903	39·35	·37	·024	·03	10·79	·14
27	42·41	39·71	2·949	39·98	·36	·023	·03	10·45	·20
June 1	43·08	40·33	2·996	40·61	0·33	0·021	0·03	10·04	·27
6	43·73	40·94	3·042	41·23	·30	·020	·02	9·55	·34
11	44·37	41·54	3·088	41·83	·27	·018	·02	8·97	·43
16	44·98	42·12	3·132	41·91	·24	·015	·02	8·31	·55
21	45·56	42·66	3·174	42·95	·20	·013	·02	7·58	·70
26	46·10	43·16	3·214	43·45	·16	·011	·01	6·79	272·85
July 1	46·59	43·62	3·251	43·91	0·12	0·008	0·01	5·92	273·00
6	47·02	44·02	3·284	44·31	·09	·006	·01	4·99	273·3
11	47·38	44·36	3·313	44·65	·06	·004	·00	4·02	273·7
16	47·67	44·63	3·337	44·91	·03	·002	...	3·00	274·4
21	47·88	44·83	3·356	45·10	·01	·000	...	1·95	275·7
26	48·00	44·95	3·369	45·21	...	...	...	0·89	280·5
31	48·05	44·99	3·375	45·24	...	...	...	0·24	59·0
Aug. 5	48·00	44·94	3·376	45·19	0·01	0·000	...	1·29	86·1
10	47·86	44·81	3·371	45·06	·02	·001	...	2·36	88·8
15	47·65	44·61	3·359	44·85	·04	·003	·00	3·40	89·7
20	47·35	44·33	3·341	44·56	·07	·005	·01	4·41	90·3
25	46·98	43·99	3·318	44·21	·10	·007	·01	5·37	90·7
30	46·54	43·58	3·290	43·80	·14	·009	·01	6·27	90·9
Sept. 4	46·05	43·12	3·258	43·33	0·18	0·012	0·01	7·12	91·1

Greenwich Noon.	Angle of Position of ♃'s Axis.		Latitude of Earth above ♃'s Equator.	Sun.	Annual Parallax.	Longitude of ♃'s Central Meridian		Corr. for Phase.
	P	L−O.	B	R	Λ−L.	(877°·90) I.	(870°·27) II.	
1890. Sept. 9	344·851	167·581	−0·404	−0·240	+7·891	81·63	125·82	−0·27
14	344·949	167·316	·413	·216	8·592	151·11	157·16	·32
19	345·018	167·129	·421	·193	9·215	220·49	188·39	·37
24	345·057	167·023	·426	·170	9·757	289·77	219·52	·41
29	345·066	166·999	·430	·146	10·218	358·95	250·55	·45
Oct. 4	345·045	167·057	−0·432	−0·123	+10·597	68·04	281·49	−0·49
9	344·994	167·196	·431	·099	10·895	137·03	312 33	·52
14	344·913	167·416	·428	·076	11·112	205·93	343·08	·54
19	344·803	167·715	·423	·052	11·251	274·74	13·75	·55
24	344·666	168 091	·415	029	11·314	343·47	44·34	·56
29	344·504	168·540	·405	−0·005	11·303	52·13	74·85	·56
Nov. 3	344·317	169·059	−0·392	+0·018	+11·223	120 72	105·30	−0·5
8	344·108	169·644	·377	·042	11·077	189·25	135·68	·53
13	343 879	170·293	·359	·065	10·867	257·72	166·00	·51
18	343·631	171·003	·339	·089	10·597	326·14	196·27	·49
23	343·367	171·769	·317	·112	10·271	34·51	226·49	·4(
28	343·088	172·586	·292	·136	9·893	102·84	256·67	·4
Dec. 3	342·797	173·452	−0·265	+0·159	+9·467	171·13	286·82	−0·3
8	342·496	174·364	·236	·183	8·996	239·40	316 94	·35
13	342 186	175·318	·205	·207	8·483	307·64	317·04	·31
18	341·870	176·309	−0·171	+0·230	+7·933	15·86	17·11	−0·27

The angle L−O+180° is the Jovicentric longitude of the Earth, reckoned in the plane of *Jupiter's* equator from O, the point of the vernal equinox of *Jupiter's* northern hemisphere or the point of the ascending node of the planet's orbit on its equator.   The angle Λ−O+180° is the corresponding longitude of the Sun, or Λ−L the difference between the two longitudes. The two values of the "longitude of ♃'s central meridian," given for each date, depend on the elements adopted in the ephemeris for 1889. As observations of the white spots in the neighbourhood of the planet's equator, which may have been made during the last opposition, have not yet reached me, I do not know how far the adopted daily rate 877°·90 of system I. represents their present motion, and must content myself with referring to the comparison of preceding observations given on p. 94 of vol. xlix.   Some observations of the remnant of the great reddish spot, kindly communicated by Mr. Denning, show that the spot preceded last year the adopted zero-meridian of system II. about six or seven minutes, so that in case the indicated acceleration of its motion has meanwhile been main-

Greenwich Noon.	Apparent Diam. Equat.	Polar.	Difference of limbs in A.R.	in Decl.	Defect of illumination. Equat.	in A.R.	in Decl.	d	w
1890.	"	"	s	"	"	s	"	°	°
Sept. 9	45·51	42·61	3·222	42·82	0·22	0·014	0·01	7·89	91·25
14	44·93	42·06	3·182	42·27	·25	·017	·02	8·59	91·37
19	44·32	41·49	3·139	41·69	·29	·019	·02	9·22	91·48
24	43·68	40·90	3·095	41·09	·32	·021	·02	9·76	91·58
29	43·03	40·29	3·049	40·48	·34	·023	·02	10·22	91·67
Oct. 4	42·37	39·67	3·002	39·86	0·36	0·024	0·02	10·60	91·78
9	41·71	39·05	2·954	39·24	·38	·025	·02	10·90	91·86
14	41·06	38·44	2·906	38·63	·38	·026	·02	11·12	91·93
19	40·41	37·83	2·859	38·02	·39	·026	·02	11·26	91·99
24	39·78	37·24	2·813	37·43	·39	·026	·02	11·32	92·06
29	39·16	36·66	2·767	36·85	·38	·026	·02	11·31	92·13
Nov. 3	38·56	36·10	2·722	36·29	0·37	0·025	0·02	11·23	92·20
8	37·99	35·57	2·679	35·76	·35	·024	·02	11·09	92·28
13	37·44	35·06	2·637	35·25	·34	·023	·02	10·88	92·36
18	36·92	34·57	2·597	34·76	·32	·021	·02	10·61	92·45
23	36·43	34·11	2·559	34·30	·29	·020	·02	10·28	92·54
28	35·96	33·67	2·523	33·87	·27	·018	·02	9·90	92·63
Dec. 3	35·53	33·26	2·489	33·47	0·24	0·016	0·02	9·48	92·73
8	35·12	32·88	2·456	33·09	·22	·014	·01	9·01	92·84
13	34·74	32·53	2·425	32·74	·19	·013	·01	8·49	92·96
18	34·39	32·20	2·397	32·42	·16	·011	·01	7·94	93·09

tained or increased, the difference may now be considerably greater.—The differences of successive values of the longitudes of ♃'s central meridian amount, for the intervals of five days, to twelve rotations in addition to the differences directly deduced, so that, for instance, the differences of the first two values are 4388°·99 and 4350°·84. The addition of the " correction for phase " to the longitudes of the central meridian gives the longitudes of the meridian which bisects the illuminated disc.

The values of the apparent diameters of the disc, &c., depend on the same data as in the ephemerides for preceding years. The formulæ employed may be found in vol. xlv. p. 508. The defects of illumination are before opposition on the preceding side and south, and after opposition on the following side and north.

The following is a list of Greenwich mean times, when the zero meridian in the assumed two systems of longitudes will pass the middle of the illuminated disc. The times of intermediate passages must be found by interpolation, the intervals

between successive passages being $9^h 50^m·40$ to $50^m·67$ in the first system, and $9^h 55^m·58$ to $55^m·85$ in the second.

	I. (877°·90)	II. (870°·27)		I. (877°·90)	II. (870°·27)
	h m	h m		h m	h m
Mar. 24	18 56·9	22 1·8	April 30	16 44·1	17 40·3
25	14 37·0	17 53·2	May 1	12 25·1	13 31·6
26	20 8·7	23 40·5	2	17 56·6	19 18·7
27	15 49·8	19 31·9	3	13 37·6	15 10·0
28	21 31·5	15 23·4	4	19 9·1	20 57·1
29	17 2·6	21 10·6	5	14 50·1	16 48·4
30	22 34·3	17 2·1	6	20 21·6	12 39·8
31	18 15·4	22 49·3	7	16 2·6	18 26·8
Apr. 1	13 56·5	18 40·8	8	21 34·1	14 18·1
2	19 28·2	14 32·2	9	17 5·1	20 5·1
3	15 9·3	20 19·4	10	12 56·1	15 56·5
4	20 40·9	16 10·9	11	18 27·5	21 43·5
5	16 22·0	21 58·0	12	14 8·5	17 34·8
6	21 53·7	17 49·5	13	19 40·0	13 26·1
7	17 34·8	13 40·9	14	15 20·9	19 13·1
8	23 6·4	19 28·1	15	20 52·4	15 4·4
9	18 47·5	15 19·5	16	16 33·3	20 51·4
10	14 28·5	21 6·7	17	12 14·3	16 42·7
11	20 0·1	16 58·1	18	17 45·7	12 34·0
12	15 40·2	12 49·5	19	13 26·6	18 21·0
13	21 12·8	18 36·7	20	18 58·1	14 12·3
14	16 53·9	14 28·1	21	14 39·0	19 59·2
15	22 25·5	20 15·2	22	2 41 Shadow of *Sat.*	
16	18 6·5	16 6·6		*IV.* crosses central meridian.	
17	13 47·6	21 53·8	22	20 10·4	15 50·5
18	19 19·2	17 45·2	23	15 51·4	11 41·8
19	15 0·2	13 36·6	24	11 32·3	17 28·7
20	20 31·8	19 23·7	25	17 3·7	13 20·0
21	16 12·8	15 15·1	26	12 44·6	19 6·9
22	21 44·4	21 2·2	27	18 16·0	14 58·2
23	17 25·4	16 53·6	28	13 56·9	20 45·1
24	13 6·4	12 44·9	29	19 28·3	16 36·4
25	18 38·0	18 32·0	30	15 9·2	12 27·7
26	14 19·0	14 23·4	31	20 40·6	18 14·6
27	19 50·5	20 10·5	June 1	16 21·5	14 5·8
28	15 31·6	16 1·8	2	12 2·4	19 52·7
29	21 3·1	21 48·9	3	17 33·8	15 44·0

	I. (877°·90)	II. (870°·27)		I. (877°·90)	II. (870°·27)
	h m	h m		h m	h m
June 4	13 14·7	11 35·2	July 10	15 12·1	11 12·6
5	18 46·0	17 22·2	11	9 6 Shadow of S. IV.	
6	14 26·9	13 13·4		10 52·9	16 59·4
7	19 58·2	19 0·2	12	16 24·2	12 50·5
	20 48 Shadow of S. IV.		13	12 5·0	8 41·7
8	15 39·1	14 51·5	14	17 36·2	14 28·4
9	11 20·0	20 38·3	15	13 17·0	10 19·6
10	16 51·3	16 29·6	16	8 57·8	16 6·4
11	12 32·2	12 20·8	17	14 29·1	11 57·5
12	18 3·5	18 7·6	18	10 9·9	17 44·3
13	13 44·4	13 58·8	19	15 41·1	13 35·4
14	19 15·7	19 45·7	20	11 21·9	9 26·6
15	14 56·6	15 36·9	21	16 53·1	15 13·4
16	10 37·4	11 28·1	22	12 34·0	11 4·5
17	16 8·7	17 14·9	23	8 14·8	16 51·3
18	11 49·6	13 6·1	24	13 46·0	12 42·4
19	17 20·9	18 53·0	25	9 26·8	8 33·6
20	13 1·7	14 44·2	26	14 58·0	14 20·4
21	18 33·0	10 35·4	27	10 38·9	10 11·6
22	14 13·9	16 22·2	28	3 16 Shadow of S. IV.	
23	9 54·7	12 13·4		16 10·1	15 58·3
24	14 57 Shadow of S. IV.		29	11 50·9	11 49·5
	15 26·0	18 0·2	30	7 31·7	7 40·7
25	11 6·8	13 51·4		17 22·1	17 36·3
26	16 38·1	9 42·6	31	13 4·0	13 27·4
27	12 18·9	15 29·3	Aug. 1	8 43·8	9 18·6
28	17 50·2	11 20·5	2	14 15·1	15 5·4
29	13 31·0	17 7·3	3	9 55·9	10 56·6
30	9 11·8	12 58·5	4	15 27·1	16 43·4
July 1	14 43·1	8 49·7	5	11 9·0	12 34·5
2	10 23·9	14 36·4	6	16 39·2	8 25·7
3	15 55·1	10 27·6	7	12 20·1	14 12·5
4	11 36·0	16 14·4	8	8 0·9	10 3·7
5	17 7·2	12 5·6	9	13 32·2	15 50·6
6	12 48·0	17 52·3	10	9 13·1	11 41 8
7	8 28·8	13 43·5	11	14 44·4	17 28·6
8	14 0·1	9 34·7	12	10 25·3	13 19·8
9	9 40·9	15 21·4	13	15 56·6	9 11·0

D D

	I. (877°·90)	II. (870°·27)
	h m	h m
Aug. 13	21 27 Shadow of *S. IV.*	
14	11 37·4	14 57·9
15	17 8 8	10 49·1
16	12 49·6	16 36·0
17	8 30·5	12 27·2
18	14 1·9	8 18·4
19	9 42 8	14 5·3
20	15 14·1	9 56·6
21	1ɔ 55·0	15 43·5
22	16 26·4	11 34·7
23	12 7·3	7 26·0
24	7 48·3	13 12·9
25	13 19·6	9 4·2
26	9 0·6	14 51·1
27	14 32·0	10 42·4
28	10 12·9	16 29·3
29	15 44·3	12 20·6
30	11 25·3	8 11·9
	15 38 Shadow of *S. IV.*	
31	7 6·2	13 58·9
Sept. 1	12 37·7	9 50·2
2	8 18·6	15 37·2
3	13 50·1	11 28·5
4	9 31·1	7 19·9
5	15 26	13 6·9
6	10 43·5	8 58·2
7	6 24·5	14 45·2
8	11 56·0	10 36·6
9	7 37·1	6 27·9
10	13 8·6	12 15·0
11	8 49·6	8 6·3
12	14 21·1	13 53·4
13	10 2·1	9 44 8
14	15 33·7	15 31·9
15	11 14·7	11 23·3
16	6 55·8	7 14·7
	9 50 Shadow of *S. IV.*	
17	12 27·3	13 1·8

	I. (877°·90)	II. (870°·27)
	h m	h m
Sept. 18	8 8·4	8 53·2
19	13 40·0	14 40·3
20	9 21·0	10 31·7
21	14 52·6	6 23·1
22	10 33·7	12 10·3
23	6 14·8	8 1·7
24	11 46·4	13 48·9
25	7 27·5	9 40·3
26	12 59·1	15 27 5
27	8 40·2	11 18·9
28	14 11·9	7 10·4
29	9 53·0	12 57·6
30	15 24·7	8 49·1
Oct. 1	11 5·8	14 36·3
2	6 46·9	10 27·8
3	4 4 Shadow of *S. IV.*	
	12 18·6	6 19·2
4	7 59·7	12 6·5
5	13 31·5	7 58·0
6	9 12·6	13 45·2
7	14 44·3	9 36·7
8	10 25·5	5 28·2
9	6 6·6	11 15·5
10	11 38·4	7 7·0
11	7 19·5	12 54·3
12	12 51·3	8 45·8
13	8 32·5	14 33·1
14	14 4·2	10 24·7
15	9 45·4	6 16·2
16	5 26·6	12 3·5
17	10 58·4	7 55·0
18	6 39·6	13 42·4
19	12 11·4	9 33·9
	22 17 Shadow of *S. IV.*	
20	7 52·6	5 25·5
21	13 24·4	11 12·8
22	9 5·6	7 4·4
23	4 46·8	12 51·7

		I. (877°·90)	II. (870°·27)			I. (877°·90)	II. (870°·27)
		h m	h m			h m	h m
Oct.	24	10 18·6	8 43·3	Nov.	21	7 41·5	11 58·4
	25	5 59·9	4 34·9		22	3 22·8	7 50·1
	26	11 31·7	10 22·3			10 44 Shadow of *S.IV*.	
	27	7 12·9	6 13·9		23	8 54·8	3 41·7
	28	12 44·8	12 1·2		24	4 36·1	9 29·2
	29	8 26·0	7 52·8		25	10 8·0	5 20·9
	30	13 57·9	13 40·2		26	5 49·3	11 8·4
	31	9 39·1	9 31·8		27	11 21·3	7 0·1
Nov.	1	5 20·3	5 23·4		28	7 2·6	12 47·6
	2	10 52·2	11 10·8		29	12 34·6	8 39·2
	3	6 33·5	7 2·4		30	8 15·9	4 30·9
	4	12 5·3	12 49·8	Dec.	1	3 57·2	10 18·4
	5	7 46·6	8 41·5		2	9 29·2	6 10·1
		16 30 Shadow of *S.IV*			3	5 10·5	11 57·6
	6	13 18·5	4 33·1		4	10 42·5	7 49·3
	7	8 59·7	10 20·5		5	6 23·8	3 41·0
	8	4 41·0	6 12·1		6	11 55·8	9 28·5
	9	10 12·9	11 59·6		7	7 37·1	5 20·2
	10	5 54·2	7 51·2		8	3 18·4	11 7·7
	11	11 26·1	13 38·6		9	4 58 Shadow of *S.IV*.	
	12	7 7·4	9 30·3			8 50·4	6 59·4
	13	12 39·3	5 21·9		10	4 31·8	12 46·9
	14	8 20·6	11 9·4		11	10 3·7	8 38·6
	15	13 52·5	7 1·0		12	5 45·1	4 30·3
	16	9 33·8	12 48·5		13	11 17·1	10 17·8
	17	5 15·1	8 40·1		14	6 58·4	6 9·5
	18	10 47·0	4 31·8		15	12 30·4	11 57·0
	19	6 28·3	10 19·3		16	8 11·7	7 48·7
	20	12 0·2	6 10·9				

The reason why in the list the times are added, when the shadow of *Satellite IV.* crosses the central meridian is: to remind observers of the favourable opportunities, which they may have during the latter part of the present apparition, of contributing by proper measurements of the coordinates of the shadow (and also of the satellite before and after its transits and occultations) to the proper determination of several elements of the orbit, as I have explained in a note published in vol. xliv., p. 241, on the last occasion, when such measurements would have been of special value.

Erratum in NAUTICAL ALMANAC *for* 1890, *p.* 454.

July 11. Transit of shadow of *Jupiter's* fourth Satellite.

$$For \quad \overset{\text{h}}{5} \overset{\text{m}}{46} \text{ and } \overset{\text{h}}{10} \overset{\text{m}}{26}$$

Read 6 46 and 11 26

Lieut.-General J. F. TENNANT, C.I.E., R.E., F.R.S., President,
in the Chair.

Sir George Errington, Bart., Lackham Manor, and Brooks's
Club, St. James's Street, S.W.;
Edward Robinson, 4 Castelnau Gardens, Barnes, S.W.;
Andrew Simons, Her Majesty's Dockyard Schools, Devonport,
were balloted for and duly elected Fellows of the Society.

The following candidate was proposed for election, the name
of the proposer from personal knowledge being appended :—

Thomas Steele Sheldon, M.B. Lond., Cheshire County
Asylum, Macclesfield (proposed by Rev. T. Harley).

On the Nautical Almanac.
By Lieut.-General J. F. Tennant, C.I.E., R.E., F.R.S.

About a couple of years ago I communicated to the *Observatory* a paper on this subject in the hopes that astronomers with
varied experiences would offer suggestions for removing imperfections in our National Ephemeris. The result was very small,
but this was not due, I think, to a belief that the Almanac is
incapable of improvement so much as to the fact that its
weakest points do not force themselves on the notice of those
who are resident near its first meridian, and who use it mainly
in preparing for or reducing observations for publication.

If we examine the contents of the *Nautical Almanac* we find
that we can arrange them under four heads with convenience.

E E

1st. *The General Ephemeris*, whose arguments are separated by equal intervals of time, and whose data are mainly materials from which the circumstances and nature of observable phenomena may be readily deduced. It is evident that these data should be given in a form which would make them most readily available for use wherever the observer may be situated. Inasmuch as the data of this section are the sources from which those of the next are derived, it follows that changes will generally be of convenience in arrangement; but there are some cases where data can be more conveniently given and also additions made of matter wanted or omissions of what has become useless.

2nd. *The Greenwich Ephemeris*, containing information more directly prepared for comparison with observation at Greenwich and readily adapted to the neighbourhood. Naturally this section requires little or no change save rearrangement.

3rd. *The Nautical Ephemeris* would much overlap the sphere of the first section: but distinctively only includes such matter as finds its use at sea, or under the circumstances of restriction in instrumental means to which travellers and explorers are subjected.

4th. *The Computing Section*, of which the contents are mainly used in computing orbits and ephemerides and in investigations connected with them.

I propose first to consider the question of arrangement which is important to convenient use, and then to pass to consider section by section the form in which the matter under each head should be given. And in the first place I would remark that in our present *Nautical Almanac* the matter under all the sections has been mixed up, so that the finding of what is wanted is less easy than it might be; and, what is worse, the user of the *Nautical Almanac* for any one purpose is encumbered with matter he does not want, or has in a more convenient form. I should therefore propose that each section should be separately paged, and, even if not sold separately, should be capable of being severed from the rest, so that everyone might combine the parts as he chose. Naturally the Greenwich Ephemeris would be of little use to the observer or worker in Australia or India: the observer in Britain would find the Greenwich Ephemeris most handy for his observatory or many other purposes; while neither would care to be constantly encumbered with the computing matter, or with that which I have above called the Nautical Section.

In each section I would place all matter relating to the Sun alone together, then the Moon, then the principal Planets in order according to their distances from the Sun; then would come the asteroids, whose ephemerides, if given, would probably only extend over part of the year; lastly the stars, and then eclipses, occultations, and miscellaneous matter. It may possibly be occasionally necessary to depart from the strictness of this

order for economy of space, but I hope not. I believe that consideration has been carried too far, and that the result of such departures from system is often too high a price to pay for the gain. In order to facilitate the determination of errors of the tables the ephemerides should contain the results deduced from those alone. Where experience shows that empirical corrections will improve the agreement with observation, those would be applied in any elements for prediction, &c., but not to the ephemeris. Thus in the case of the Moon, Hansen's Tables would be used corrected for the error in Table xxxix. (where one included term is wrong in sign and value), but the other corrections proposed by Professor Newcomb would be applied before forming the elements for eclipses and occultations.

I now proceed to consider the contents of the First Section, and I shall refer to the pages of the *Nautical Almanac* of the current year containing each item.

* I doubt if the Mean time of Transit of First point of *Aries* is of much practical use.

Remarks on above.—The mode of putting the Moon's semi-diameters and parallaxes below the Polar coordinates of the day, adopted in the *Connaissance des Temps*, seems to me convenient. I would add in the same way the mean times of the transits; the phases might, as now, close the month, or be placed at the beginning of the Almanac. I have entirely omitted the Moon-culminating Ephemeris, which in its present form I look on as valueless save for Greenwich. If the times of transit and the coordinates of the Moon could be given for each hour of longitude, somewhat as in the *Connaissance des Temps*, they would be useful; but it is a question if the gain would be worth the cost. If anyone will try to use the present Table of Moon-culminating places for the purpose of determining the right ascension of the Moon's centre, or that of the limb, and the hourly motion, say at Madras, he will be satisfied that there is a more ready way of gaining his object.

As regards the Stars. The list should be greatly increased. There should be no difficulty about this. The *Berliner Jahrbuch* gives a list of the mean places of 622 stars of which the ephemerides are given for some 450, and the *Connaissance des Temps* gives ephemerides for 360. Uniformity would require that the places should be given for mean noon or midnight at Greenwich, and I do not think that this would be practically inconvenient; but as stars are generally observed on the meridian, the present arrangement offers advantages and might stand. Eclipses and occultations should have their elements given so as to facilitate as much as possible the computation of local phenomena. The arrangement of elements of occultations in the *Connaissance des Temps* is the most complete, but that of the American *Nautical Almanac* is more compact, and practically suffices. A similarly convenient form is to be found in Dr. Anton's *Ephemeris*, published at Trieste, in which the data are taken from the *Nautical Almanac*. The mode of giving the elements for eclipses recently in the *Connaissance des Temps*, and, from somewhat similar formulæ, in the American *Nautical Almanac*, seems to me to offer most convenience for use.

I see no reason why the information as to Satellites should be confined to *Jupiter's*, and have included those of all planets known to have any. I should like to see a uniform system for enabling the observer to recognise the configurations. The mode of exhibiting those of *Jupiter's* satellites is unsatisfactory when the times of observation differ from those employed; but there are of course other means of distinguishing these satellites than their positions.

I would suggest further that the Star ephemeris might be made a sub-section so that it could be attached to any of the sections which may be preferred.

2nd. *The Greenwich Ephemeris* would contain

Solar Ephemeris at Transit	p. i. of month
Lunar Ephemeris, being Moon-culminating Stars, omitting Lower Transit	pp. 369–398
Mercury at Transit	270–273
Venus ,, ...	274–277
Mars ,, ...	278-281
Jupiter ,, ...	282–284
Saturn ,, ...	285-287
Uranus ,, ...	288-289
Neptune ,, ...	p. 290
Eclipses for British Observatories	401
Occultations at Greenwich	pp. 441–443
Satellites of Jupiter, Eclipses, &c., for Greenwich	444–465

I should propose to extract the eclipses of *Jupiter's* satellites, &c., from the general list so far as they are visible in the United Kingdom. I presume in all other matters English astronomers have secured almost all that they especially want, and that any changes will be very trifling.

3rd. *The Nautical Section.*—Considered merely as a portion of the volume this would contain only

Lunar Distances, pp. xiv. to xviii. of mo.	
Table for 2nd Difference Correction	p. 482
Tables for correcting Lunar Distances for the Earth's figure.	
Table for Latitude by Polaris	pp. 483–485
,, ,, Azimuths by ,,	
,, ,, Tides	476–479

I have added a table for azimuths by *Polaris* because I think this would be useful to surveyors, and not less so in navigation, especially in low latitudes. I should very much like to see tables, such as those in the *Berliner Jahrbuch*, for correcting lunar distances for the effects of the figure of the Earth; they would be probably rarely used at sea, but would be valued by all careful observers everywhere. As regards tides, I should like to see tide tables given for the principal ports whenever there are data for computing them accurately, as there now are, I believe, for many points on the coast. The cost of mechanical computation would be but trifling, and there seems no reason why London should be the sole tidal station. As a rule I fancy that heights, unless readily convertible to heights over a bar or shallow, would not be of much use to seamen.

Lastly we come to the *Computing Section.* The ephemerides

in this would be latitudes and longitudes, but all data would be referred to the equinox of the beginning of the year when the Sun's longitude is 280°. ·The contents would be:—

The matter contained in page 1 of the *Nautical Almanac*, save that the mean obliquity and precession should be referred to the above date instead of January 1·0.

The Sun's Longitude, Latitude, and Log Rad Vector ... p. iii. of month.

The Sun's Co-ordinates for Mean Equinox of above date pp. 218–225

The Moon's Latitude, Longitude ...   . p. iv. of month.

Empirical Corrections to Moon's Latitude, Longitude ... pp. xv. & xvi. of App.

Mean Longitudes, &c., of Moon and its Node.

Heliocentric Longs., Lats., and Distances, Mercury				226–233
,,	,,	,,	Venus	234-241
,,	,,	,,	Mars	242–249
,,	,,	,,	Jupiter	250–257
,,	,,	,,	Saturn	258–265
,,	,,	,,	Uranus	266–267
,,	,,	,,	Neptune	268–269

Mean Places of Stars   292–295

Bessel's Formulæ of Reduction ...   . p. 296

  ,,   Day Numbers   ...   . pp. 297–304

  ,,   Independent Constants   305–312

Day of Year, and Corresponding Day of Julian Period.·

Latitudes and Longitudes of Observatories.

In the *Berliner Jahrbuch* the latitudes and longitudes of the Moon are only given to one-tenth of a minute. This accuracy would suffice for the Moon, and equally for the smaller planets, but (unless space be wanting) I would propose to give them all to the nearest second. *Jupiter* and the planets beyond should have them given to $0''\cdot1$. In the cases of the planets daily places would be unnecessary, but I would propose that they be given for every fifth day of the Julian Period; thus, in the current year the dates would run January 2, 7, 12, &c. I should be very glad to see the co-ordinates of the planets given for the same dates referred to the same planes as those of the Sun. It does not seem necessary to give corrections of these to the apparent equinox of the day either for Sun or planets, but as regards the latter there would be an advantage in a correction to the equinox of a preceding and succeeding year, say the even tenth years preceding and succeeding. These co-ordinates could be computed as a step in passing from the Heliocentric longitudes and latitudes to the Geocentric right ascensions and declinations.

In the *Nautical Almanac* the places of the stars are referred to the beginning of the fictitious year, but the mean equinox for

other purposes is that of January 1·0. There seems no reason for this variation, and I have proposed that, as in the *Connaissance des Temps* and the *Berliner Jahrbuch*, the beginning of the year should have only one meaning—that is, the moment when the Sun's mean longitude is 280°.

If the values of the day numbers in the *Nautical Almanac* be compared with those of the *Connaissance des Temps*, it will be found that towards the end of January and December there is a considerable difference between the C's and the D's. This is due to the fact that the terms of the expression for Nutation, depending on the longitude of the solar perigee, are omitted in the *Nautical Almanac*. There is also an additional quantity E omitted which is applicable to the right ascensions, and whose maximum value is $\pm 0''\cdot 05$ or $\pm 0^s \cdot 0033$. All these are very small quantities, but it does not seem right that they should be neglected when we consider the accuracy with which modern observations are reduced, as well as the fact that in the *Nautical Almanac* smaller periodic terms than some of these are retained. The quantities g, G, and f of the Independent Constants also require correction for the effects of the same terms. It appears unnecessary to continue Airy's day numbers, which are not required for use with the recent Greenwich Catalogue, and have never been required for the catalogues of other observatories. In fact, Mr. Stone's tables for finding a, b, c, &c., supersede all special calculations for the star numbers if his constants be accepted, and render Bessel's day numbers alone necessary when an ephemeris or several places of a star are required. Where it is a question of reducing single or very few observations of stars, the independent constants are best. The means of applying the terms of Nutation, which depend on the Moon's longitude, and change rapidly, should be given. This can be done in two ways. Their effects on C, D, f, g, and G, can be given separately, or they can be included at once in the daily values. The former plan is theoretically preferable, and I think the effects should be tabulated with the Moon's longitude as argument, for the change of arguments in a day is too great for convenient interpolation of the numbers, and this difficulty is only concealed, and not removed, by the latter practice, which, however, has the authority of the *Berliner Jahrbuch*. When any of the day numbers change sign, passing through o, the logarithms become so irregular that their interpolation is impossible. In these cases it is desirable to give the natural numbers instead of the logarithms, with some suitable warning. In the *Berliner Jahrbuch* the natural numbers are given in addition to the logs., but this is hardly necessary. In the independent constants, also, log. i should be replaced by i under similar circumstances.

In what has preceded, I have spoken of the Nautical Section as a part of the General Almanac, but I do not think that the wants of navigation and geography will be met as fully as they should be by this arrangement. I have long felt that a smaller

volume, which should omit all that was not useful to the
wanderer, would be a boon ; and the existence of various
ephemerides, containing selections from the *Nautical Almanac*,
with tide tables, and various information as to special ports,
shows that the want has been felt in England, though no official
attempt has been made to meet it.   Elsewhere the case is
different.   In America, under the title of the *American Nautical
Almanac*, a small volume * has been annually published for the
use of navigators, and this, again, has been further simplified
in two smaller volumes, for the especial use of coasters on the
East and West coasts respectively.   The German Government
have published at Berlin, under the editorship of Dr. Tietjen, a
very handy volume called the *Nautisches Jahrbuch* ; and more
recently the Austrian Government have published at Trieste a
volume called the *Astronomische Nautische Ephemeriden*, edited
by Dr. Anton, of which the text would seem to be given in
more than one of the languages of that Empire.   France, too,
has begun a series of extracts from the *Connaissance des Temps*,
for the use of the Marine.   Of these I think the Berlin volume
would be far the best type to follow.   The arrangement, in-
deed, is not that which I prefer, but it would be intelligible to
those using it.   With slight exceptions, it contains all that a
surveyor or traveller by land or sea can want.   One short-
coming is in the Elements of Occultations, where, though the
data suffice for calculating a longitude from an observed occulta-
tion, they do not at once do so for predicting the circumstances
for a given place, the power of doing which is essential to any
systematic use of occultations.   In this respect Dr. Anton's
volume is more satisfactory.   Both should, I think, give the
elements and charts for eclipses.   I do not think the data for
Jupiter's satellites are of much use.   They may occasionally
furnish an approximate longitude when the stay at a station is
very short ; but for anything like satisfactory observation they
require more optical means than the traveller generally has—
means requiring carriage facilities which I think would justify
our expecting him to adopt a better mode of determining longi-
tude than lunar distances.

Some sixty years ago, a Committee of our Society, under
authority from the Admiralty, devised the arrangement of the
Nautical Almanac substantially as it now exists ; small changes
have been made, all in the direction of advance, but the lapse of
time seems to me to make it desirable that there should be a
new committee representative of the interests concerned.   And
I do not think that the plan of starting the changes determined
on, and leaving the matter to official supervision, is quite satis-
factory.   I should like to see a more permanent consultative

* This is in fact extracted from the General American Ephemeris, which
will be found of late years to be divided into sections somewhat as I have
proposed.   Professor Newcomb has been good enough to send copies of these
Nautical Publications through me to the Library.

body, whose duty it should be to receive, consider, and decide on questions of proposed changes. The *Nautical Almanac* comes in contact with such large classes of men scattered over the world, that it is hardly possible that the experience of one or two officials in London can meet all the wants of those using it. It is no reflection, then, on those who have had the guidance of our ephemeris that they have not succeeded perfectly in an impossible task; indeed, that after some sixty years of uncontrolled management, the *Nautical Almanac* is so little behind the times is the best testimony to the care which has been given to it. But we should not be content with this. A Nation whose ships are in every Sea, and whose Colonies surround the globe, should not be content to lag behind, but should be amongst the leaders in giving facilities for its widely-scattered astronomers, mariners, and geographers.

P.S.—The Astronomer Royal has stated that Hansen's Tables include empirical terms, and I believe that some of his co-efficients have been determined so as to make the Tables agree with observation; theory, however, prescribed the arguments and the numbers are Hansen's. Two of Newcomb's corrections are purely empirical and have no foundation in theory, and the other three, which I have proposed to print in the Ephemeris, arise from changes made in Hansen's data; they may be improvements, but they cannot be considered part of Hansen's Tables.

Note on the Apparent Star Places of the Nautical Almanac.
By H. H. Turner, M A., B.Sc.

In the course of the longitude operations recently under-taken at the Royal Observatory, Greenwich, occasion arose for comparing the places of the circumpolar stars given in the *Nautical Almanac* with those of other almanacs, viz. the *Connaissance des Temps*, the *Berliner Jahrbuch*, and the *American Ephemeris*, which will hereafter be designated *C.T.*, *B.J.*, and *A.E.* respectively. The meridians being different, simple interpolation must be used for such comparisons, except in the case of the *N.A.* and *C.T.*, where the difference of meridians is so small as to render this unnecessary.

The apparent places may be regarded as the sum of two terms: (1) the adopted mean place, and (2) the star correction. The first depends on previous observations generally selected from national sources, and is therefore different in different almanacs; but the second is a mere matter of computation, the elements for which are known with such accuracy that the results might be expected to agree very closely.

The original comparison referred to the years 1889 and 1890, and it was found that for these years the star corrections for

Polaris of the *N.A.* and *C.T.* did not show a satisfactory agreement. The *N.A.* was then compared with other ephemerides, and other years were examined, and the following notes of the results may be of interest.

Previous to 1875 the "terms depending on 2 ☽," as they are generally called, were not incorporated in the printed star places of the *N.A.*, but a separate table was given to facilitate the application of these terms for the five circumpolars. The comparison with other almanacs for circumpolar places thus involves some labour, and it will be convenient to begin with the year 1875. From 1875 to 1887 the agreement between the places of the *N.A.* and the *C.T.* is quite satisfactory, the differences for right ascension of *Polaris* ranging over about o^s·10 throughout the year. A curious exception must be made of the first year (1875) itself, when these differences are so accurately constant as to make anyone who has had experience of independent computation somewhat suspicious. It may be remarked that the *N.A.* for 1875 was published in 1871, and the *C.T.* in 1873.

For these years then we may bracket the two almanacs together; and the remark made by Professor Auwers in the *B.J.* for 1884, Appendix, p. 92, will probably apply to the whole period 1875–1887. After stating that the *B.J.* and *A.E.* agree sensibly from the year 1883 onwards, he proceeds:—"The *N.A.* and the *C.T.* agree in their reductions. Both set down the principal lunar term in the formula, but neglect it in the computed values of A, B, C, D, and in the 10-daily ephemerides (for non-polar stars); but, besides this, they quite unnecessarily neglect sensible terms of long period, thus introducing errors amounting to o″·25. Without considering terms which up to 70° declination do not singly reach o″·002, the following corrections are thus applicable to the reductions from mean to apparent place as given in the *C.T.* and *N.A.* :—

$$\Delta(\Delta a) = +o''\cdot135 \sin(\odot + 82°\cdot2) - o''\cdot003 \sin 2 \odot - o''\cdot046 \sin \Omega,$$
$$+ o''\cdot059 \sin(\odot + 82°\cdot2) \sin a \tan \delta,$$
$$- o''\cdot009 \cos(\odot + 280°\cdot9) \cos a \tan \delta.$$
$$\Delta(\Delta\delta) = + o''\cdot059 \sin(\odot + 82°\cdot2) \cos a + o''\cdot009 \cos(\odot + 280°\cdot9) \sin a."$$

It does not appear that any notice has been taken of this remark in these almanacs to the present time, so that computations based on these ephemerides require the corresponding small corrections—for instance, the places of the Greenwich Ten-Year Catalogue (1877–1886).

But there remains a curious discrepancy. From the year 1888 the agreement between the *N.A.* and *C.T.* for right ascensions of close circumpolars exists no longer, the range of difference for *Polaris* being more than o^s·50. The N.P.D.s are apparently unaffected.

The following table exhibits the range of discordance in apparent places of *Polaris* between the *N.A.* and *O.T.* for various years :—

Year.	Range in R.A.	Range in N.P.D.
	s	″
1875	0·00	0·0
1880	0·09	0·3
1883	0·19	0·3
1886	0·18	0·4
1887	0·18	0·3
1888	0·57	0·2
1891	0·46	0·2

Concerning the reason for this discrepancy M. Lœwy kindly informs me that from 1888 the formulæ of Fabritius have been used in obtaining apparent places for the *O.T.*, and this change would appear to be an advantage on comparing the *O.T.* and *N.A.* respectively with other ephemerides. The following table shows the range of the differences in the apparent R.A.'s of the four circumpolars for the year 1890 :—

				B.J.-N.A.	B.J.-C.T.
				s	s
Polaris	...	...	...	0·45	0·12
Cephei 51	...	...	...	0·29	0·04
δ Ursæ Minoris	...	...		0·21	0·04
λ Ursæ Minoris	...	...		0·86	0·13

With regard to the N.P.D.s it may be questioned whether computation to one place of decimals is quite enough. It is apparently to this that we may trace the discordances ranging one or two tenths on either side of zero, which thus become sensible. The range corresponding to $0''\cdot3$ in right ascension of *Polaris* would be $0^s\cdot3 \div 15 \sin \mathrm{N.P.D.} = 0^s\cdot9$, about which some care is taken in computation. There appears to be no reason for withholding the same care from N.P.D. computations; and this remark would apply to all stars.

Photograph of Stars in the region of Tycho's Nova.
By Isaac Roberts.

The photograph which accompanies this communication was taken on January 12, 1890, with an exposure of the plate during 2 hours and 55 minutes. The right ascension at the middle of the plate is about $0^h\ 16^m$, and the declination north $63°\ 18'$. Four pencil lines, enclosing a rectangular space, are drawn on the photograph, so as to correspond with the chart of this region made by D'Arrest in 1864, and the position of the *Nova*, as given by him, is shown marked by a white circle.

D'Arrest has charted the stars to the 16th magnitude, and the photograph, when examined with a magnifier, shows them to probably the 17th magnitude.

There is no appearance of either a nebula or of a star on the photograph in or about the position indicated by D'Arrest, namely, R.A. 0^h 17^m 7^s, Decl. $+63°$ $23''.5$, but if we compare D'Arrest's chart and catalogue of the stars with the photograph, it will be seen that changes have taken place both in the positions and magnitudes of several of the stars since 1864. The following particulars will illustrate some of these changes; but they are not to be considered as a complete discussion of D'Arrest's chart. The stellar numbers and coordinates of the positions are those given by D'Arrest.

The star No. 15, R.A. 0^h 15^m 13^s, Decl. $63°.9$, is shown on the chart to be 13th magnitude, but on the photograph it is only about 17th magnitude.

The star No. 72, R.A. 0^h 16^m 20^s, Decl. $63°$ $13'$, magnitude 11–12, has changed in its position-angle to the extent of about $55°$, from south following to south preceding the 11–12th magnitude star, No. 69, R.A. 0^h 16^m 17^s, Decl. $63°$ $14'$.

The double star No. 153, magnitude 14, R.A. 0^h 17^m 45^s, Decl. $63°$ $22'$, has changed its position-angle by moving towards the preceding side with reference to the star No. 159, magnitude 11–12, R.A. 0^h 17^m 51^s, Decl. $63°$ $23'$.

The 11th magnitude star, No. 83, R.A. 0^h 16^m 34^s, Decl. $63°$ $26'$, does not appear on the photograph.

The two stars, No. 100, R.A. 0^h 16^m 49^s, Decl. $63°$ $11'.6$, and No. 97, R.A. 0^h 16^m 48^s, Decl. $63°$ $13''.5$, have changed in magnitude from 11th to about the 16th.

The 12–13th magnitude star, No. 120, R.A. 0^h 17^m 12^s, Decl. $63°$ $50'$, has changed its position-angle by moving about $30°$ towards the south following direction.

The 11th magnitude star, No. 203, R.A. 0^h 18^m 52^s, Decl. $63°$ $27'.4$, has changed in its position-angle about $35°$ towards the north following direction.

The 11th magnitude star, No. 37, R.A. 0^h 15^m 45^s, Decl. $63°$ $32'$, has changed its position-angle with reference to the star No. 36, magnitude 11, R.A. 0^h 15^m 44^s, Decl. $63°$ $34'$, from south following to south preceding.

The star No. 33, R.A. 0^h 15^m 40^s, Decl. $63°$ $36'$, magnitude 10–11, does not appear on the photograph.

The following group of four stars are not recognisable on the photograph, and no stars appear exactly where they are shown:—

Star No.		h	m	s		°	'	
3,	R.A.	0	14	53,	Dec.	63	37·6,	10–11th Mag.
4,	„	0	14	53,	„	63	38·7,	11th „
8,	„	0	15	3,	„	63	37·6,	11th „
12,	„	0	15	8,	„	63	38·2,	10th „

The changes which have now been particularised are important when we consider that they apply to less than half a degree in right ascension, and one degree in declination; but there are two causes of uncertainty to be taken into account before we can give full acceptance to the objective reality of these changes

1st. Photographic magnitudes of stars do not all agree with those which have been determined by eye observations, and this fact may account for some of the differences in the magnitudes.

2nd. There may be errors in the charting by eye observations, notwithstanding the greatest care and skill on the part of the observer, but any uncertainties that may appertain to them, as well as to the subject matters of this communication, can now be removed by those who possess the necessary optical power; for the exact nature of the changes to be determined has been pointed out by photography, and the essential data furnished for the purpose. That the stars, Nos. 3, 4, 8, 12, 33, and 83, which have been referred to as shown on D'Arrest's chart, and not shown on the photograph, are absent on the latter on account of some physical change having taken place in the stars, receives confirmation by the fact that the photograph shows more than 400 stars on a sky space where D'Arrest has charted only 212 stars.

I am indebted to Dr. Pechüle, of Copenhagen, for a copy of D'Arrest's chart and catalogue, and he informs me that he has for some years kept a watch upon the region of the *Nova*.

Note on the Sun-spots of 1889.   By E. W. Maunder.

Though the Sun-spots of 1889 were few in number and generally small in area they presented some characteristics of especial interest; for the past year saw the close of one cycle of solar activity and the commencement of a new one, and the peculiar features of a transition period were well illustrated by the spot-groups which came under observation.

General Features of the Sun-spot Record of 1889.

From every point of view 1889 was a less fertile year than those which preceded it. Without going back to 1884 or 1885—years of great activity—it may be useful to compare it with 1886 and the two succeeding years, for in 1886 there was a lull of so pronounced a character in the late autumn as to lead one experienced solar observer to regard it as probably the true minimum. The following table shows how 1889 compares with the years preceding it as to days without spots, number of spot-groups observed, and mean daily spotted area:—

Year.	Days of Observation.	Days without Spots.	No of Spot-groups.	Mean Daily Spotted Area.
1886	363	61	128	381
1887	361	106	79	179
1888	358	155	54	89
1889	359	209	32	77

The areas in the above and in the following tables are expressed in millionths of the Sun's visible hemisphere.

There can be no doubt, therefore, that the minimum did not fall before 1889.

Duration of Spot-groups.

A marked feature of the spot-groups of 1888 had been the tendency of the disturbances to be intermittent. Amongst the fifty-four spot-groups of that year there was not a single case of a group being seen through the whole of three semi-rotations, nor even through the whole of two; though in one instance a group was seen during part of three successive rotations, and in another case a group was seen during part of two successive rotations. These were the only two examples of a group returning to the east limb after its disappearance at the west limb. But whilst the continuous life-history of a group tended to be short, there were several cases—nine in all—in which a district was the seat of an intermittent action, an interval of rest prevailing between the different outbreaks. The following table shows the localities in which this intermittent action was observed :—

No. of Group.	First Seen.		Last Seen.		Hel. Long.	Hel. Lat	Mean Area.
2075	Nov.	11	Nov.	22	15.6	− 4.0	193
2077	Dec.	9	Dec.	9	19.7	− 3.7	9
2043	March	31	March	31	142.2	− 1.0	7
2050	April	25	April	29	144.8	− 1.5	15
2064	Aug.	12	Aug.	22	143.5	− 2.6	29
2030	Jan.	12	Jan.	16	148.6	− 13.3	24
2049	April	24	April	29	153.4	− 13.3	47
2055	June	19	June	19	163.4	− 12.7	11
2070	Sept.	6	Sept.	16	163.8	− 14.9	57
2072	Oct.	3	Oct.	3	166.8	− 14.5	22
2076	Nov.	27	Dec.	9	163.3	− 11.8	217

Group 2064 was not seen on August 17, nor on August 19 and 20.

| 2048 | April | 21 | April | 27 | 184.3 | − 2.8 | 36 |
| 2069 | Sept. | 6 | Sept. | 10 | 185.8 | − 0.3 | 16 |

Group 2069 was not seen on September 9.

No. of Group.	First Seen.		Last Seen.		Hel. Long.	Hel. Lat.	Mean Area.
2047	April	18	April	18	243·5	− 6·7	15
2051	April	28	April	28	247·4	− 7·5	5
2054	June	15	June	19	257·8	− 10·0	30
2059	July	10	July	17	266·2	− 10·1	65

Group 2059 was not seen on July 12.

2052	May	11	May	23	273·5	− 7·8	443
2058	July	6	July	7	272·6	− 6·9	10
2063	Aug.	8	Aug.	10	274·5	− 8·1	28
2066	Aug.	28	Sept.	9	276·7	− 6·1	248
2035	Feb.	18	Feb.	29	297·3	− 4·7	220
2042	March	25	March	25	299·0	− 4·6	3
2053	June	9	June	16	301·9	− 4·6	52
2062	Aug.	1	Aug.	2	304·9	− 5·8	17
2068	Aug.	31	Aug.	31	301·7	− 3·3	10

A tenth group, group 2060, was lost for a single day (July 18). Longitude 150°·3, latitude +6°·0.

In marked contrast to this tendency to intermittent action shown by the spot-groups of 1888 we find in 1889 only four examples, two of them but very slightly marked, in which spots broke out a second time in a district after an intervening period of rest. But whilst the examples of this intermittent action were fewer and less distinct than in 1888, there was an increased tendency to more persistent displays.

The following table shows the duration of the different groups during the last four years. It will be seen that with a total of thirty-two groups as against fifty-four in 1888, the number of groups seen in a second or third rotation was twice as large in 1889 as in the preceding year :—

Duration of Group.	Number of Groups.			
	1886.	1887.	1888.	1889.
1 day	20	11	12	4
2 days	17	9	9	6
3 „	17	9	5	3
4 „	7	9	2	0
5 „	6	7	4	1
6 „	6	5	1	2
7 „	4	3	2	2
8 „	6	2	3	0
9 „	1	2	1	1
10 „	1	5	0	1
11 „	5	2	4	1
12 „	8	3	3	0

Duration of Group.		Number of Groups.		
	1886.	1887.	1888.	1889.
13 days	1	2	3	1
14 „	0	1	0	0
2 rotations	6	5	1	2
3 „	3	0	1	2
4 „	1	0	0	0
5 „	1	0	0	0
Total No. of groups	128	79	54	32
Total No. of separate groups, deducting for reappearances	110	75	51	26
Mean observed duration of a group	10 days	7 days	6 days	11 days

The following table gives the four regions where intermittent action was observed in 1889 :—

No of Group.	First Seen.		Last Seen.		Hel. Long.	Hel. Lat.	Mean Area.
2081	Feb.	1	Feb.	6	31·9	− 3·5	60
2090	June	16	June	28	30·7	− 5·5	501

Group 2090 was seen in the two succeeding rotations as groups 2092 and 2099.

2093	July	14	July	20	84·4	− 7·7	33
2098	Aug.	9	Aug.	17	79·5	− 7·2	335
2101	Sept.	3	Sept.	4	83·6	− 9·4	7
2103	Sept.	24	Oct.	4	152·5	−20 9	141
2107	Oct.	23	Oct.	23	154·1	−22·5	2

Group 2103 had been seen in the two preceding rotations as groups 2097 and 2100.

2087	April	11	April	12	203·0	− 1·2	15
2096	July	29	Aug.	4	200·5	− 0 9	64

Distribution in Latitude.

The most striking feature of the spot-groups of 1889 was the appearance of a number of spots in high latitudes. In accordance with their behaviour in previous cycles the spots had tended to approach more and more nearly to the equator from the time of the previous minimum in 1879.

Year.	Mean Distance from Equator of all Spots.	Year.	Mean Distance from Equator of all Spots.
1879	22·82	1884	11·27
1880	19·80	1885	11·76
1881	18·21	1886	10·38
1882	17·81	1887	8·44
1883	13 04	1888	7·39

In 1888 only one spot out of the fifty-four groups had a higher latitude than 15°, and that spot lasted but for a single day; but ten lay between 15° and 10°, whilst the remaining forty-three clustered still nearer to the equator. The downward tendency was continued in 1889. Up to June 29 no spot had a higher latitude than 10°, and throughout the year there was only one instance of a group lying within either of the zones 20° to 10°, and in that case it was only for a part of its duration that its latitude was less than 20°; its mean latitude on the whole being 20°·5 S. But in the latter half of the year there were several instances of groups in latitudes higher than 20°, so that the groups of 1889 were divided into three well-defined and widely separated zones—a high northern zone, an equatorial zone, and a high southern zone, with a barren belt 10° wide separating the equatorial zone from the zones of high latitude on either hand.

We may look upon the equatorial zone as containing the last remains of the spots of the expiring cycle, whilst the high zones show the first efforts of the new cycle.

	Under 10°.	Mean Daily Area of Sun-spots. 10° - 20°.	Above 20°.	Total.
1886, Jan.–June	352	255	1	608
July–Dec.	100	59	1	159
1887, Jan.–June	84	49	0	134
July–Dec.	194	29	0	223
1888, Jan.–June	89	4	0	93
July–Dec.	66	20	0	86
1889, Jan.–June	53	0	0	53
July–Dec.	52	0	51	103

The southern hemisphere has still preserved that predominance which it has shown, almost without break, ever since the closing up of the great northern spot of November 1882.

	Equatorial Zone. No. of Groups.	Mean Daily Area.	Above 20° Lat. No. of Groups.	Mean Daily Area.
Northern	4	4	2	1
Southern	16	48	10	25

Distribution in Longitude.

In years of minimum such spots as appear are usually confined to two or three limited areas. This was very remarkably the case in 1889. The great group of June 16 in its three appearances as groups 2090, 2092, and 2099 contributed more than 41 per cent. of the spotted area of the year, or, including the preliminary outbreak in the same region in February, 42 per cent. The great group of August 2 made up 26 per cent. in its successive appearances as groups 2097, 2100, and 2103. These

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two groups, therefore, embraced between them about 68 per cent. of the entire spotted area. The region of longitude 83° and latitude —8° came third with 12 per cent., so that all the other groups put together contained but little more than 20 per cent.

Localities of Formation and Dissolution.

Of the twenty-six separate groups of the year, eighteen formed and dissolved in the visible hemisphere, and were seen only in one rotation; three formed and dissolved in the visible hemisphere, but were seen in more than one rotation; two formed on this side of the Sun, but were dissipated on the other; one formed on the other side, but was dissipated on this; and two, of which one was seen only in one rotation, but the other in three, formed and dissolved in the unseen hemisphere.

Dividing the visible hemisphere into thirteen lunes, each 13°·2 of longitude in breadth, so that each lune corresponds to the mean apparent distance traversed by a spot in a single day, and placing the seventh so that the central meridian should bisect it, the number of cases of spot-formation and spot-dissolution for each lune or day are as follows:—

Lune or Day.	Formations.	Dissolutions.	Ephemeral Spots.	Total No. of Separate Spots.	Total Area.
First	0	0	0	9	1293
Second	1	0	0	13	1695
Third	5	0	1	33	1866
Fourth	2	2	0	50	1756
Fifth	2	1	1	76	1806
Sixth	2	2	0	65	2242
Central	1	0	0	72	2459
Eighth	0	1	1	102	2527
Ninth	1	2	0	102	2407
Tenth	2	1	0	73	2568
Eleventh	2	1	0	50	2642
Twelfth	0	8	0	34	2701
Thirteenth	1	0	1	14	1720

It will be seen that neither the total spotted area nor the number of separate spots was divided symmetrically with respect to the central meridian, the western quarter-sphere having a most distinct advantage over the eastern in both particulars. On the other hand, more groups formed to the east of the central meridian, and more were dissipated to the west of it; the third day being the most favourable for spot-formation, and the twelfth for their extinction. But the number of groups under observation in either quarter-sphere was nearly the same; seven groups being seen only in the east, and nine only in the west, whilst six-

teen were observed on both sides of the central meridian. The preponderance of number of spots and of spotted area observed in the western half of the visible hemisphere was therefore due to the tendency of groups to increase in size and complexity after the central meridian was passed.

Though the example of a single year, and that a year of minimum, is wholly insufficient to base any deductions upon, it will be at once recognised that if a long series of years showed any similar want of symmetry in spot-distribution, it would lead us to the conclusion that our Earth exercised a real influence over the behaviour of the spot-groups, and would render it highly probable that *Venus* and *Jupiter* exerted an influence considerably greater, whilst the establishment of a practical symmetry over a term of years would disprove the existence of any appreciable planetary influence at all. It seems to me, therefore, that this is a point for very careful investigation in the future. The want of symmetry in the present instance may, I think, be regarded as purely accidental, being due to the sudden revival of activity on the ninth day in the case of two important groups, and to the formation of another considerable group at the same apparent meridian.

Characteristics of Spot-groups.

Thirteen of the groups of 1889 were seen only on one, two, or three days. Of these, twelve were but small in size and presented no important peculiarities, except that of position; six of them lying in high latitudes as under:—

No. of Group.	First Seen.	Last Seen.	Hel. Long.	Hel. Lat.	Mean Area.
2091	June 29	June 30	251·1	−40·3	5
2094	July 26	July 27	342·1	−24·2	66
2104	Oct. 8	Oct. 8	12·1	−28·8	12
2105	Oct. 9	Oct. 11	23·4	−25·3	8
2106	Oct. 16	Oct. 18	328·9	+22·3	15
2107	Oct. 23	Oct. 23	154·1	−22·5	2

The thirteenth group, group 2102, was distinguished by the development of a large spot in advance of the rest of the group, on the last day on which it was visible before passing out of sight at the west limb. The group followed group 2100 on the same parallel of latitude but at a distance of about 10° in longitude, and there appeared to be a species of attraction between the two groups, the preceding group moving backwards, and the following group forwards. It is far more common to see examples of apparent repulsion.

Of the remaining thirteen groups the five following consisted

of a number of small spots irregularly scattered. In each case the group underwent very rapid changes, increasing to a maximum in two or three days, and then fading away almost as quickly.

Group.	First Seen.	Last Seen.	Hel. Long.	Hel. Lat.	Mean Area.
2081	Feb. 1	Feb. 6	31·9	− 3·5	60
2082	Feb. 22	March 3	111·9	− 7·1	55
2093	July 14	July 20	84·4	− 7·7	33
2096	July 29	Aug. 4	200·5	− 0·9	64
2109	Dec. 18	Dec. 22	168·1	+ 24·1	34

One group, group 2088, consisted of a large circular spot, which broke up on the third day into a stream of small spots. The course of a number of groups as watched in the visible hemisphere suggests that this group had been in existence some ten or twelve days before its appearance at the east limb.

Three groups, groups 2083, 2098, and 2110, illustrate to some extent a type of spot-history often witnessed amongst the more important groups, but three of the four groups of long duration afford much better examples of it. In this type of spot the outbreak commences with a few small faint spots very irregularly distributed. By the second or the third day a great change has taken place; there is a strong forward motion in the group; the spots tend to arrange themselves in a long straight stream, generally along or but slightly inclined to a parallel of latitude. The spots rapidly increase in number and size, especially towards the two ends of the stream. Soon the group consists of two large spots with a few much fainter and smaller spots between them. Of the two large spots the leader is usually the larger, is very regular and well defined in outline, and for a time moves forward very rapidly in longitude. The last spot of the group is nearly stationary, not so regular in shape, and soon breaks up. The fainter and smaller spots in the centre of the group disappear, leaving the two principal spots alone. The following spot after breaking up soon disappears also, and the leader is left alone. The lifetime of the leader as a solitary circular spot is of very various duration, sometimes only a day or two, sometimes it continues through several complete rotations. It disappears either by breaking up into small fragments, or, preserving its shape, gradually contracts until nothing is left.

Of the four long-duration groups of the year, the group seen in two rotations as groups 2108 and 2111 was a single circular spot. The other three groups, the positions of which are given below, are examples of the type of spot just described :—

Group.	First Seen.		Last Seen.		Hel. Long.	Hel. Lat.	Mean Area.
2085	March	13	March	17	$308°2$	$+ 6°2$	110
2086	April	1	April	11	$315·1$	$+ 5·3$	71
2090	June	16	June	28	$30·7$	$- 5·5$	501
2092	July	12	July	24	$36·3$	$- 7·9$	318
2099	Aug.	9	Aug.	20	$36·9$	$- 8·1$	73
2097	Aug.	2	Aug.	11	$161·5$	$-20·7$	336
210ɔ	Aug.	27	Sept.	7	$160·4$	$-19 3$	198
2103	Sept.	24	Oct.	4	$152 5$	$-20 9$	141

All three groups were distinguished by the remarkable manner in which they moved about on the solar surface, not only in longitude but also in latitude.

The first group moved forward $5°·2$ in longitude, and $0°·6$ upward in latitude, in the four days following its formation. In the fortnight that it was on the further side of the Sun it moved forward $4°·0$ in longitude, and $1°·1$ downward in latitude. It was now a single circular spot, and remained nearly stationary till its disappearance.

The second group, that of June 16, the principal group of the year, showed the most extraordinary drift, as the first diagram will show.

Some of the minor irregularities are probably due to faculous or photospheric matter drifting above portions of the group and concealing certain districts of it, revealing them again by their withdrawal later on. But as for the greater part of its history, the group practically consisted of but one well-defined circular spot, there can be no doubt that the apparent change of place from day to day corresponds very closely to the real movement of the centre of the group upon the solar surface. In this and in the second diagram the observed positions for the first and last days at each appearance are not given, as only a portion of the group was visible on some of those occasions, and the centre of the part observed was therefore not the true centre of the group.

The third group of long duration, that of August 2, was a very perfect example of the type above described. The first faint spots were seen on August 2. By August 4 the long stream of spots with a large spot at either end had fully formed; and by August 11 the leader alone remained. During the next rotation the group consisted only of one large circular well-defined spot. At its third appearance this circular spot was preceded by a number of small spots, but after September 26 the entire group, and especially the smaller spots, began to diminish, and the group had disappeared before reaching the west limb. The most striking feature in the history of the group was the rapid backward drift shown after its first appearance. The forward movement during the first rotation, the retrogression whilst on the

further side of the Sun, and during the second appearance, and the irregular drifting shown in the third illustrate well the difficulty in obtaining any trustworthy rotation period. This
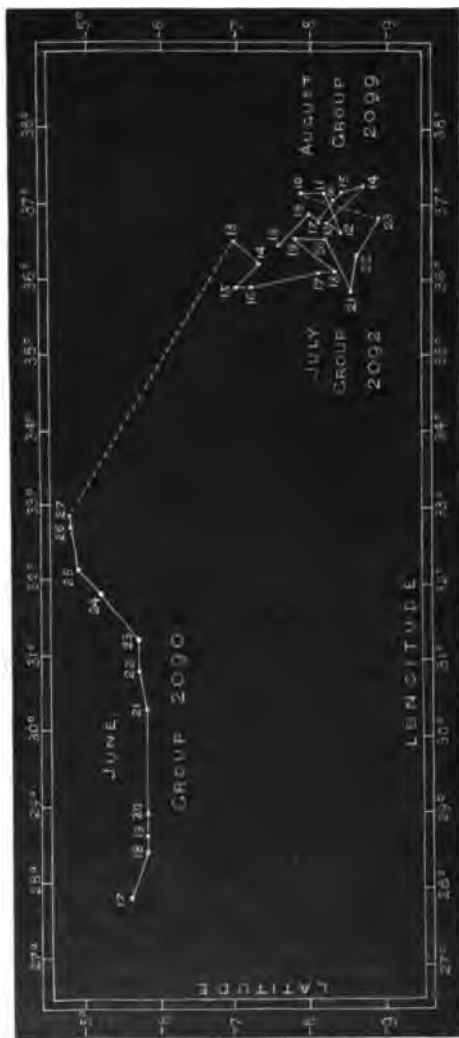
one group would have given three very different rotation periods from its three different appearances, viz. 24·1 days, 25·8 days, and 25·5 days. Carrington's period for this latitude would be 25·7 days. The rotation-period adopted in this paper for the

computation of the heliographic longitudes has been 25·38 days throughout.

The following diagram shows the apparent course of the group during the three appearances.
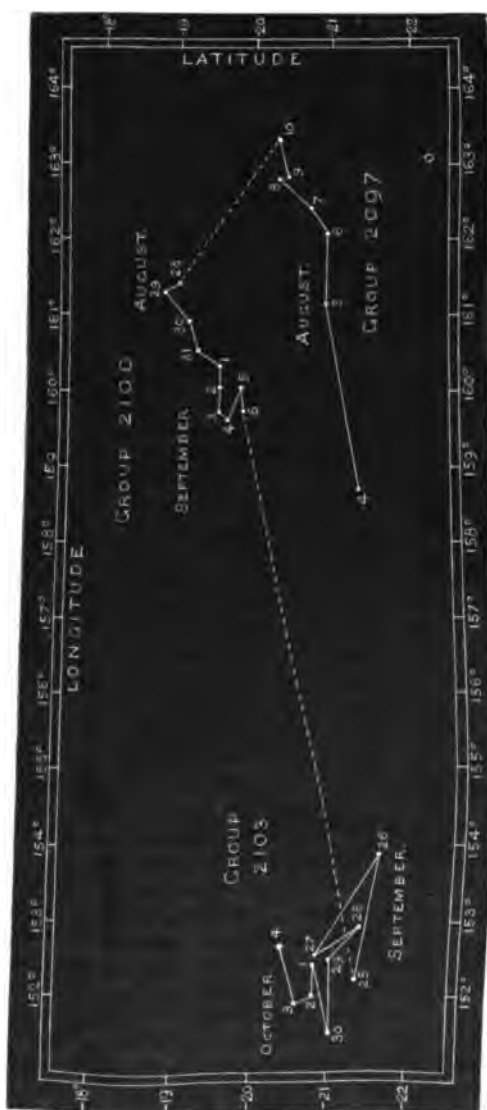
Summary.

The chief features of the Sun-spots of 1889 are:—

1. The Sun-spots were fewer and smaller than in 1888.
2. But the second half of 1889 was more prolific than the first half.
3. In the second half of the year several spot-groups appeared in high latitudes, so that the spots were congregated in three distinct zones.
4. The average duration of a group was double what it was in 1888. There was less tendency to intermittent action, and a greater tendency to continued action.
5. Some of the larger groups showed a drift remarkable for rapidity and irregularity.

A Mechanical Theory of the Solar Corona. By J. M. Schaeberle.

My investigations seem to prove conclusively that the solar corona is caused by light emitted and reflected from streams of matter ejected from the Sun by forces which, in general, act along lines normal to the surface   These forces are most active near the centre of each Sun-spot zone.

On account of the rotation of the Sun the nearer portions of the stream will have a greater angular velocity than the more distant parts, resulting in a stream of double curvature, each individual particle of the stream, however, describing the same conic section, which for velocities less than about 383 miles per second is a very eccentric ellipse (assuming that the Sun's atmosphere is very rare, as is apparently shown by various observations).

Owing to the change in the position of the observer with reference to the plane of the Sun's equator (according as he is above, below, or in this plane), the perspective overlapping and interlacing of the two sets of streamers causes the observed apparent change in the type of the corona.

In the diagrams numbered 5, 6, and 7 I have purposely exaggerated the curvature of the streams in order to show more forcibly the perspective effect when viewed from different parts of the Earth's orbit. All the other illustrations are prints made from the same model, in which the Sun is represented by a ball something over an inch in diameter, from which radiate a number of needles to represent the streams of matter. All these needles are contained between two small circles corresponding to 30° of north and south latitude, the longer ones being found near the middle of each zone, and slightly more inclined to the normal than the shorter ones, in order that the more distant portions of

the needles (representing the outgoing streams) shall have inclinations roughly the same as required by physical laws.
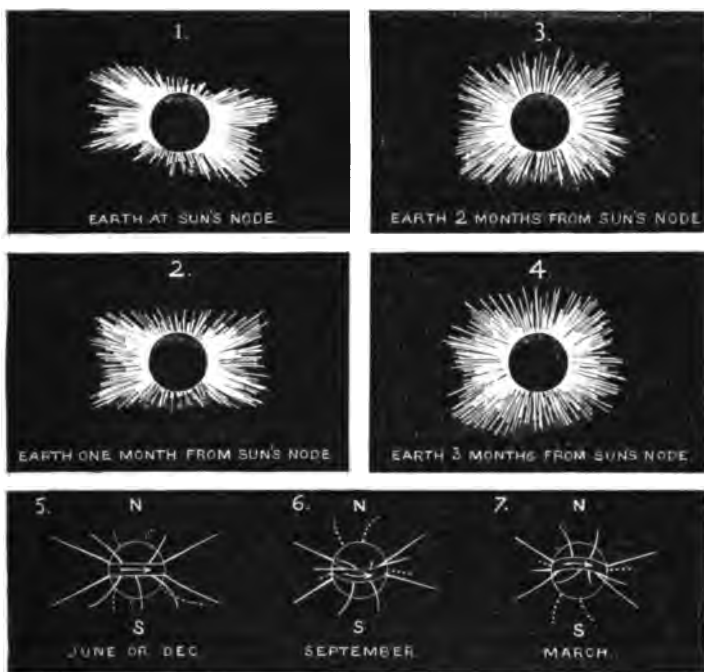
When the model is placed in a beam of parallel rays and its shadow allowed to fall upon a screen, an infinite variety of forms can be produced by simply revolving the model, although an effort was made to secure a symmetrical arrangement of the needles in the two zones.

The illustrations show the changes due to the apparent variation of the inclination of the Sun's axis to the line of sight.

> No. 1 Earth at Sun's node.
>
>   2 Earth one month from Sun's node.
>
>   3   „   two months „   „
>
>   4   „   three months „   „

A discussion of the mechanical theory, together with a comparison showing the remarkable agreement with observation, will appear in the report of the eclipse of December 22, 1889.

Mount Hamilton:
   1890 *March* 18.

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The Structure of the Sidereal Universe.   By T. W. Backhouse.

(Abstract.)

Curves of stars have often been noted in the heavens, but less attention has been paid to what the writer has found to be a far more striking and prevalent feature, of which this paper more especially treats—*straight* lines and *parallel* arrangements of pairs, lines, and bands of stars, and also of irresolvable wisps.

A special small area of the sky, viz. that portion of the Milky Way included between 15, 13, 8 *Monocerotis, a Orionis, ζ Tauri,* and 5, μ, ξ *Geminorum,* has been selected for detailed scrutiny; and the descriptions refer chiefly to the configurations in this area. The observations have been made by the author during the last eight years, and nearly all of them at Sunderland; some are features noted by unaided vision, but most of them were gleaned by the use of a binocular field-glass of 2·05 inches aperture; a refracting telescope of 4¼ inches aperture being occasionally used.

The details are exhibited in tabular form in the original paper, and include features noticed in Argelander's *Atlas des nördlichen gestirnten Himmels.* Though the field-glass shows nearly as many stars as the maps, the same features are not always found, two suggested reasons for this being that stars separately too faint to be inserted in the maps may be impressed upon the eye by their united light; and, on the other hand, the appearance of a line may be destroyed by surrounding stars. Proctor's chart of the whole of Argelander's stars was also examined for comparison, and for the great cluster in *Gemini* the MM. Henry's photograph of that object.

The paper contains the following sections :—

Part I.—Lines and parallel arrangements of stars.
Part I*a.*—Lines and parallel arrangements in clusters.
Part II.—Nebulous wisps.
Part II*a.*—Nebulæ.

In these are given the detailed structure in different parts of the area, showing the various systems of parallel lines and wisps, together with their position-angles referred to that portion of Gould's Galactic Equator (vide *Uranometria Argentina,* p. 371), which runs through the middle of the area in question. For comparison are also given the position-angles, referred as above, of several well-recognised circles in the heavens as

Part III.—Miscellaneous lines.

Many of the details described are obvious on the most casual glance, and nearly all are conspicuous on careful scrutiny.

There is, besides the parallelisms, a most wonderful case of

radiation of stars and wisps in a fan-shaped group, 68 *Orionis* being approximately the centre. The only counterpart to this which the author has seen is one on a far larger scale, visible to the naked eye, but much less striking; viz. a radiation from near the Pole star to the Milky Way in the semicircle from ε *Ursæ Minoris* to β *Camelopardi.*

Two maps and five figures accompany the paper; the latter exhibit the groupings of the various position-angles, showing a preponderance at an average deviation of 15° from the direction of Gould's Galactic Equator, viz. at a position-angle of 345° with that great circle, and more nearly parallel with a Galactic Equator derived from Proctor's chart of the *Durchmusterung* stars. There is a marked deficiency of position-angles at right angles to the Galactic Equator of those in the great cluster 35 *Messier*, as well as of the wisps.

The terms "nebulous wisps" and "nebulosity" have been given to that faint and diffused luminosity, usually in long and narrow bands, which when viewed with higher powers is sometimes resolved into stars, sometimes remains partially or wholly unresolved, and sometimes disappears altogether. When resolved, it in some cases shows very small and densely packed stars, in others widely scattered stars not much too faint to be individually visible with the lower power.

One conclusion derived from the investigation is that the stars and wisps in parallel lines are probably in the same region of space; and therefore that the majority of the stars—at least of those down to the 9th or 10th magnitude—in extensive tracts of the area examined are really near one another.

The paper is offered as a contribution to a subject till lately much neglected, in the hope that the observations will be supplemented by those of others, whether in confirmation or otherwise.

Discovery of Comet Brooks 1890. By William R. Brooks.

I have the honour to announce to the Society my discovery, on March 19, 16 hours (standard, 75th meridian time), of a new comet in approximate R.A. $21^h 9^m$, Dec. $+5° 35'$. I at once felt confident that the object was a comet, for the region has been thoroughly searched many times, and I had no record of a nebula in that place. On turning to Dr. Dreyer's "New General Catalogue of Nebulæ," published in the *Memoirs* of the Royal Astronomical Society, it was found that the nearest nebula recorded there was No. 7045=J.H. 2108, which was 2° away, and marked e F, while my object was quite bright. The morning dawn advanced rapidly, however, and obliterated the object before I was positive of motion, but suspected a slight motion northward. The Harvard, Lick, and Warner Observatories

were therefore promptly notified of the suspected object, with a request to verify. With myself the three succeeding mornings were tantalisingly cloudy. On the fourth morning, however, March 23, at 16 hours, it was beautifully clear, and turning the telescope to the place I at once found the comet less than one and one half degrees north, and slightly east of the discovery position, and in approximate R.A. 21^h 10^m 30^s, Dec. $+ 7°$ $15'$. This gave a daily motion of 22^s east, and $25'$ north. The two telescopic fields are shown in figs. 1 and 2, fig. 1 being the field of discovery.
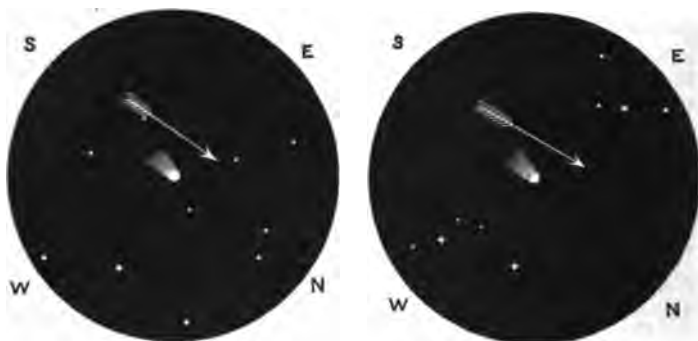
1. Discovery field of Comet Brooks,   2. Telescopic field of Comet Brooks,
      1890 March 19^d 16^h.   1890 March 23^d 16^h.

The comet is rather bright, telescopic, with stellar nucleus, and a short, broad tail. The discovery was made with the $10\frac{1}{2}$-inch refractor, with a chromatic positive eyepiece, giving a mag. power of 40, and a field of $1°$ $20'$.

Smith Observatory, Geneva, N.Y., U.S.A.:
        1890 March 24.

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Lieut.-General J. F. TENNANT, C.I.E., R.E., F.R.S., President,
in the Chair.

John William Aldridge, 14 Hansford Street, Hackney Road,
N.E.;
Thomas William Brownell, 26 Lincroft Street, Moss Side,
Manchester;
George Cumes, F.R G.S., Huntingdon House School, Ted-
dington;
George Henderson, M.R.A.S., &c., Ovenden, Sevenoaks;
Frank Robbins, 154 Oakley Street, Chelsea, S.W.,

were balloted for and duly elected Fellows of the Society.

The following candidates were proposed for election, the
names of the proposers from personal knowledge being
appended:—

Robert Isaac Finnemore, J.P., F.R.Hist.Soc., Durban,
Natal (proposed by P. Edward Dove);
William Friese-Greene, Photographer, 92 Piccadilly, W.
(proposed by James Glaisher);
George Higgs, 467 West Derby Road, Liverpool (proposed by
A. Cowper Ranyard);
Neville Holden, Solicitor, High Street, Lancaster (proposed
by Squire T. S. Lecky);
Harold Jacoby, B.A., Columbia College Observatory, New
York City, U.S.A. (proposed by David Gill).

H H

Mean Areas and Heliographic Latitudes of Sun-spots in the Year 1889, deduced from Photographs taken at Greenwich, at Dehra Dûn (India), and in Mauritius.

(Communicated by the Astronomer Royal.)

The results here given are in continuation of those printed in the *Monthly Notices*, vol. xlix. p. 380, and are deduced from the measurements of solar photographs taken at the Royal Observatory, Greenwich, at Dehra Dûn, India, and at the Royal Alfred Observatory, Mauritius.

Table I. gives the mean daily areas of umbræ, whole spots, and faculæ for each synodic rotation of the Sun in 1889, and Table II. the same particulars for the entire year. The areas are given in two forms : first, projected areas—that is, as seen and measured on the photographs, these being expressed in millionths of the Sun's apparent disc ; and, next, areas as corrected for foreshortening, the areas in this case being expressed in millionths of the Sun's visible hemisphere. Table III. exhibits for each rotation in 1889 the mean daily area of whole spots, and the mean heliographic latitude of the spotted area, for spots north and for spots south of the equator, together with the mean heliographic latitude of the entire spotted area, and the mean distance from the equator of all spots ; and Table IV. gives the same information for the year as a whole.

TABLE I.

No. of Rota- tion.	Date of Commence- ment of each Rotation.	No. of Days on which Photo- graphs were taken.	Projected.		Mean of Daily Areas. Corrected for Foreshortening.		
			Umbræ.	Whole Spots.	Faculæ.	Umbræ.	Whole Spots.	Faculæ.
		d						
471	1888 Dec. 15·33	26	3·8	30·8	107	2·9	23·9	121
472	1889 Jan. 11·66	26	4·0	27·8	57·2	2·5	16·6	76·2
473	Feb. 8·00	27	5·9	33·6	75·1	3·4	20·0	79·6
474	Mar. 7·34	27	7·1	41·1	116	6·3	37·8	·137
475	Apr. 3·64	27	4·7	32·7	38·9	2·7	18·7	46·9
476	Apr. 30·90	27	2·7	15·2	66·7	2·4	16·6	80·5
477	May 28·12	27	44·5	245	79·0	29·0	160	84·3
478	June 24·31	27	50·0	277	128	37·4	214	165
479	July 21·52	25	73·9	448	280	54·8	345	343
480	Aug. 17·74	27	22·4	122	131	17·9	101	175
481	Sept. 14·00	27	14·4	77·7	125	10·4	58·6	151
482	Oct. 11·28	28	0·2	2·6	72·1	0·1	1·9	93·0
483	Nov. 7·58	27	0·0	0·0	45·0	0·0	0·0	58·0
484	Dec. 4·89	27	14·1	81·9	166	12·7	76·3	214

TABLE II.

Year.	No. of Days on which Photographs were taken.	Mean of Daily Areas.					
			Projected.		Corrected for Foreshortening.		
		Umbræ.	Whole Spots.	Faculæ.	Umbræ.	Whole Spots.	Faculæ.
1889	360	17·9	103	107	13·1	78·0	131

The rotations in Table I. and Table III. are numbered in continuation of Carrington's series (Observations of Solar Spots made at Redhill by R. C. Carrington, F.R.S.), No. 1 being the rotation commencing 1853 November 9. The assumed prime meridian is that which passed through the ascending node at mean noon on 1854 January 1, and the assumed period of the Sun's sidereal rotation is 25·38 days. The dates of the commencement of the rotations are given in Greenwich civil time, reckoning from mean midnight.

TABLE III.

No. of Rotation.	Date of Commencement of each Rotation.	No. of Days on which Photographs were taken.	Spots North of the Equator.		Spots South of the Equator.		Mean Heliographic Latitude of Entire Spotted Area.	Mean Distance from Equator of all Spots.
			Mean of Daily Areas.	Mean Heliographic Latitude.	Mean of Daily Areas.	Mean Heliographic Latitude.		
471	1888, Dec. 15·33	26	0·0	...	23·9	− 6·63	− 6·63	6·63
472	1889, Jan. 11·66	26	2·8	+ 10·16	13·8	− 3·60	− 1·28	4·71
473	Feb. 8·00	27	0·0	...	20·0	− 7·18	− 7·18	7·18
474	Mar. 7·34	27	31·6	+ 6·08	6·2	− 7·16	+ 3·92	6·26
475	Apr. 3·64	27	17·6	+ 3·32	1·1	− 0·95	+ 3·06	3·18
476	30·90	27	0·0	...	16·6	− 2·03	− 2·03	2·03
477	May 28·12	27	0·0	...	160	− 5·94	− 5·94	5·94
478	June 24·31	27	0·0	...	214	− 6·64	− 6·64	6·64
479	July 21·52	25	7·6	+ 2·69	338	− 13·78	− 13·42	13·54
480	Aug. 17·74	27	0·0	...	101	− 19·18	− 19·18	19·18
481	Sept. 14·00	27	0·0	...	58·6	− 21·08	− 21·08	21·08
482	Oct. 11·28	28	1·6	+ 22·70	0·3	− 25·20	+ 15·34	23·08
483	Nov. 7·58	27	0·0	...	0·0	...	...	...
484	Dec. 4·89	27	6·2	+ 24·27	70·0	− 20·90	− 17·21	21·17

TABLE IV.

Year.	No. of Days on which Photographs were taken.	Spots North of the Equator.		Spots South of the Equator.		Mean Heliographic Latitude of Entire Spotted Area.	Mean Distance from Equator of all Spots.
		Mean of Daily Areas.	Mean Heliographic Latitude.	Mean of Daily Areas.	Mean Heliographic Latitude.		
1889	360	5·0	+ 7·26	73·0	− 11·90	− 10·68	11·61

The foregoing tables would appear to show that the actual Sun-spot minimum fell during the past year. The mean daily

spotted area for the year as a whole was decidedly smaller than for 1888, whilst towards the end of the year there was a marked tendency for spots to form in high latitudes, so that the mean distance from the equator of all spots was considerably greater than in 1888. As Professor Spoerer has pointed out, the appearance of spots in high latitudes usually indicates the commencement of a new cycle. If the present be an example of this rule, then the new cycle may be taken as commencing in June 1889; for there were no instances of spots in latitudes higher than 10° until June 29, when a spot appeared in S. lat. 40°. At the same time the mean daily spotted area increased notably, for whilst it was only 22·5 for the first six rotations of 1889, as against 89 for 1888, it rose to 202 for the four following rotations. On the other hand, however, there have been but few spots since this outburst came to an end, and it may eventually prove to have been a mere accidental and temporary revival, and not the true commencement of the new cycle. The course of the solar activity during the next few months can hardly fail to decide the point.

Totality of the Eclipse of 1889 December 22. By David P. Todd.

(Communicated by Dr. Huggins.)

I located the eclipse expedition just north of Cape Ledo, a bold bluff on the West African coast, about 75 miles south of Saint Paul de Loanda.

Totality was completely lost in clouds, but a brief general description of the apparatus for the total eclipse, and of the novel method of operating it, will not be inappropriate.

Three essentials were recognised : (1) A great variety of apparatus ; (2) large-scale pictures of the corona ; (3) perfect clockwork. I saw no better way to meet these conditions than by constructing an equatoreal stand sufficiently capacious to accommodate all, or nearly all, the photographic apparatus. Accordingly, a split polar axis was built of 6-inch wrought-iron tubes, about 11 feet long, and placed 2 feet apart. The whole was mounted English fashion, on massive cast-iron supports, capped with brass bearings. This was built by Mr. Saegmueller, of Washington, and I was fortunate in obtaining from him the loan of a very perfect and powerful clockwork to drive it. This latter was in process of construction for the great equatoreal refractor of the Denver Observatory, and I found its centrifugal governor, a triple-twist flexible steel spindle, to perform with the highest accuracy. Also, the means provided by Mr. Saegmueller for adjusting the polar axis into parallelism with the earth's axis proved to be very neat; and the adjustment was readily made so close that, with an hour's run of the clock, the declination error on the plate did not exceed 20″.

On this axis was mounted all the photographic apparatus for the total eclipse, and a high-power directing telescope to verify the pointing of the whole.

This comprised the following apparatus :—

1. Professor Pickering's reversing-layer spectroscope, for photographing a spectrum trail for 15 seconds both before and after second and third contacts.

2. Five photographic telescopes, the first a Clark $\frac{150}{8}$ doublet, twelve exposures, two being through a Carbutt orthochromatising screen; the second a Dallmeyer $\frac{38}{6}$ rapid rectilinear lens, sixteen exposures; the third a Dallmeyer $\frac{24}{6}$ rapid rectilinear lens, four exposures; the fourth a Ross $\frac{44}{5}$ portrait lens, eighteen exposures; and the fifth a Gundlach $\frac{22}{3\cdot75}$ aplanatic orthoscope, with one specially-prepared plate for the extreme outer corona, and other circum-solar objects.

3. Two catoptric telescopes by Brashear, with twenty-five exposures for each, the first having the ratio $\frac{33}{8}$, with the central 3 inches of the mirror sacrificed to the plate-holder; while in the second, $\frac{72}{8}$, the entire aperture was made available by setting the plate-holder at one side of the tube, and tilting the mirror slightly, as in the Herschelian form of mounting.

4. Five dioptric telescopes, with objectives uncorrected for the actinic rays, the first a Clark-Merz $\frac{96}{6\cdot4}$ objective, twenty-five exposures, of which five were made with the full aperture, and five each with apertures of 5, 4, 3, and 2 inches; the second, a Schroeder $\frac{22}{6}$ triple objective, one hundred exposures; the third, a Clark $\frac{72}{5}$ telescope, with the Sun's image enlarged to 4·5 inches diameter, four exposures; the fourth, a Spencer $\frac{36}{4}$ objective, eighteen exposures, divided among apertures varying from 1 to 4 inches; the fifth, a Clark $\frac{49}{3\cdot5}$ objective, twenty-five exposures. This latter instrument was intended to provide pictures precisely comparable with those of the eclipse of 1889 January 1, taken by Mr. Barnard; and, accordingly, the aperture of the objective was capped down to 1·75 inches.

5. Two flint-glass spectroscopes, and one quartz spectroscope, provided by Harvard College Observatory.

6. Two duplex cameras for photographing the polarisation of the corona, prepared by Dr. Wright, of Yale University.

7. A duplex telescope of 75 inches focal length, for coronal photometry, prepared by Professor Bigelow, who also got all the spectroscopes into readiness for the eclipse.

The finder, or directing telescope, was a $7\frac{1}{4}$-inch Clark refractor, with a high-power eyepiece.

In all, the apparatus mounted upon the polar axis embraced two mirrors and twenty-three objectives.

The operation of it by hand, as ordinarily, would of course have been impossible. My experience during the eclipse in Japan two years previously had suggested the desirability of automatic operation of all eclipse apparatus; and, as a result of much experimentation with different electric and pneumatic devices, I finally ventured to adopt the pneumatic valve system covered by the letters patent of Mr. Merritt Gally.

By means of this unique system, which has been largely employed in the automatic playing of musical instruments, a very small current of exhaust air—say of one-tenth inch diameter—is made to control an exhaust current very many times greater in volume.

A system of forty-eight such valves offered no difficulties of construction whatever, and was built in ten days' time, under the immediate personal supervision of the inventor. The tubes leading from the valve ports were of half-inch diameter. The control currents were governed by a succession of one-tenth inch apertures punched in a strip of paper about 9 inches wide and 7 feet long. This I wound upon the barrel of an ordinary chronograph, so that it should unwind at a perfectly uniform rate when the chronograph was set going. As the paper left the barrel, it passed over the " tracker," and was rewound upon a take-up roller. The whole was mounted over an exhaust organ-bellows, strongly built, and with springs of triple tension. This combined apparatus made a perfect pneumatic commutator, having forty-eight air currents in perfect control. In order to set any current in motion, it was only necessary to puncture the control sheet at a point whose x was equal to the time, and whose y corresponded to the number of the air port in the " tracker."

From the commutator, half-inch lead pipes were run to the position of the different mechanical devices which were to come into action during totality. Here they were connected with small pneumatic bellows of the ordinary V-pattern.

Each bellows, then, was so connected by appropriate mechanical movements that its collapsing thrust should perform the various sorts of work required, whether the operation of an exposing shutter, the revolution of a Nicol, the variation of available aperture, or the shifting of a photographic plate.

In such a variety of apparatus, it was impossible that one form of mechanical movement should suffice for the whole. The

requirements of some of the instruments were best met by shutters, which the pneumatic bellows held open against the action of a spring during the full length of the exposure, while others required that alternate actions of the pneumatic should open and close the shutter, or exposing-slide. This was easy enough; but the problem of changing the sensitised plates for new exposures turned out to be much more difficult, especially where a large number of exposures was required.

Where the plates were small and the exposures few, a sliding plate-holder was found to work best; here it was only necessary to fasten a ratchet to the back of the plate-holder, and then attach a pawl to the vibrating side of the bellows. But some of the plates were of the size 17 inches by 20, and they could not be advantageously managed in this way. I finally hit upon the idea of attaching them to a revolving crate or barrel, set in motion on its axis by means of a small weight fastened to a cord wound upon a pulley or wheel at one end. An escapement-wheel was then placed on the barrel, with detents equal to the number of plates, and each detent so adjusted that when at rest its corresponding plate lay in the focal plane of the objective. A very small pneumatic then sufficed as a pallet, or as a trigger to set off the mechanical device on the conclusion of each exposure. This simple movement was found to be sure of action, easy of construction, and to require a minimum of time for shifting the plates.

Also, the capacities of other devices for shifting plates were tried. At the focus of one of the smaller instruments a plate was set in a small frame sliding laterally in a frame of twice its own dimension, and this latter again sliding longitudinally in a shallow box of twice the dimension of the outer frame. By means of three pneumatic bellows, appropriately set and fitted with ratchet movements, every part of the sensitive plate was brought to the centre of the focal plane, and the exposure duly made.

For the reflectors it was found best to employ an endless chain or belt of plates, double-hinged together by means of continuous flexible tapes.

In order to test the utmost capacity of the automatic apparatus, and at the same time to furnish a large series of pictures of the same corona with a given instrument, a quick-acting lens was rigged with a long plate-barrel, sliding automatically forth and back in a frame rigidly attached to the tube. The barrel had ten plate strips upon it, and the ratchet movements gave ten exposures for each strip. In this manner one hundred exposures, from a half-second to two seconds long, were readily obtained with a single instrument.

In order to avoid the construction of a camera-box for each telescope, I adopted the plan of mounting the polar axis near the middle of a house, one end of which had a removable roof, while the other formed a dark room. The spaces between all the

instruments in the axis were readily stopped, and a partition athwart the house was built up underneath the axis and down from the rafters of the house. It was then a simple matter to connect the partition with a wooden frame around the exterior of the polar axis, by means of heavy opaque cloth secured to the partition and the frame, with sufficient slack to allow the necessary motion of the polar axis and all the instruments mounted on it.

It may be further stated that substantially all this apparatus for the automatic movements was devised, constructed, and tested at sea, during the voyage of the U.S.S. " Pensacola " from New York to Saint Paul de Loanda.

Notwithstanding the evident impossibility of securing any pictures of the corona, as a thick cloud stood nearly stationary over the Sun at the time of totality, the pneumatic commutator was brought into operation, and the control chronograph set going 15 seconds before the predicted time of second contact. The duration of totality was 190 seconds, and over 300 exposures were made. The automatic movements of exposing-shutters and the other apparatus in the uncovered portion of the house were apparent; while, in the absence of pictures on the plates, the accurate registration of the movable plate-holders was rendered certain by the subsequent examination of marks so placed upon the slides as to disclose any failure of the mechanism to act.

Two other instruments of the expedition were ready for use during the total eclipse, and deserve mention here on account of their unusual proportions; one of them—the 40-foot direct photo-heliograph—which Professor Bigelow's ingenuity had provided with a sand-clock of extraordinary precision, and a sliding plate-holder for obtaining three photographs of the inner corona during totality; and the other—a 20-inch silver-on-glass mirror, of 75-foot focus—kindly lent to the expedition by Professor Langley, and which was so mounted as to throw an image of the corona into a huge camera-box set upon a cliff which lay fortunately just beneath the Sun at the time of totality. Here a 10-inch image of the Sun came to focus, beautifully defined, and 20 × 24 inch plates of the highest sensitiveness were prepared for exposure. But during totality both these unusual telescopes were also rendered inoperative by clouds.

The Apparent Projection of Stars upon the Bright Limb of the Moon at Occultation, and similar Phenomena. By Professor George Davidson, Ph.D., Sc.D., U.S. Coast and Geodetic Survey.

(*Communicated by the President.*)

In the *Observatory* for February 1890, upon p. 72, the Astronomer Royal is reported to have called attention to an occultation of a star by the Moon, among the occultations of 1889 at the Royal Observatory, that presented matter of "interest."

On September 16 Mr. Turner observed the occultation of ζ *Tauri* by the bright limb of the Moon, with the Lassell reflector of 24 inches, and Mr. Lewis with a refractor of three and three-fourths inches. Mr. Turner noted "no projection : disappeared instantaneously at bright limb." Mr. Lewis noted that "the star touched the limb of the Moon five seconds before the observation, and was slightly inside the limb. It appeared as a brilliant spot in the Moon, and disappeared suddenly at the time given above." On p. 69, Mr. Ranyard says that "in the case of *Jupiter* there are cases . . . . where one or two stars have apparently been seen through the limb of the planet. There are such a number of these observations that we cannot doubt that the planets have not a sharp limb, they seem to be surrounded by an atmosphere of great depth, or rather a gaseous envelope in which clouds or dusty matter float in irregular masses."

I have frequently seen this question brought forward with such unsatisfactory explanations that perhaps you will grant me the opportunity to present a few instances from my own experience, and my explanation of the phenomenon. My experience extends through forty-seven years as an observer, and to elevations reaching ten and eleven thousand feet above the sea.

In 1848 or 1849, during daylight, I observed the occultation of a *Scorpii* by the bright limb of the Moon, using a transit telescope with probably two and one-half inches aperture and low power. The red star touched the bright limb and I noted the time mentally, but as the star did not disappear I continued the watch for about two and one-half seconds longer, when the red star was unmistakably within the apparent limb. It disappeared instantaneously, and I noted that time also. I at once submitted the case to my chief, who said the time of disappearance was the true time of the occultation, but gave no explanation. I then submitted the observation to Superintendent Bache, who wrote to either Herschel or Airy on the subject. The reply was that he personally had never observed the phenomenon, but that there were some similar cases on record. However, he gave no explanation.

In the Survey of Admiralty Inlet and Puget Sound, about 1855, I again observed the occultation of a *Scorpii* by the bright

limb of the Moon at night, with phenomenon similar to that of 1848 or 1849. I probably used a three-inch Fraunhofer and moderate power.

My continuous geodetic and astronomical duties have long since led me to a solution of these and many somewhat similar appearances. *A spurious limb of the Moon is formed by the unsteadiness of our own atmosphere immediately surrounding the station of the observer.* This unsteadiness of the atmosphere throws the disc of the Moon into irregular vibrations of small amplitude and short duration; and from the same cause the star is not sharply defined as a steady point, but is seen fuzzy, flickering, and unsteady, with a bright nucleus.

The star approaches the actual limb of the Moon and both partake of the unsteadiness; but if the nucleus of the star be large and coloured, the impression of its image upon the eye is more intense than the image of the whitish, confused, spurious edge of the Moon, even when the former is inside the latter. The action of the eye is selective, and the effort is greater with the less favourable condition of a white star. There is no effort and no need of selection to receive an impression of the image of the Moon's limb, although it may be seen with high power.

The impression of the star's image is therefore continuous within the range of amplitude of the excursions of the disc of the Moon, but is instantly lost when the limit of range is reached and the actual limb of the Moon passes over the star.

With a large, coloured star the phenomenon is unmistakable; with a white star it may be somewhat in doubt; with a small white star it will very probably not be noted.

I have witnessed similar phenomena when the satellites of *Jupiter* have been occulted by the planet. In this case my fellow-observer with the smaller telescope, say of two and one-half or three inches, loses the satellite much sooner than I observe its disappearance in my 6·4-inch Clark equatoreal; and this will always occur with the larger objective and the higher power. When the atmosphere is steady and the limb of the planet sharply defined the above phenomenon is absent. When the atmosphere is remarkably steady the bright limb of the Moon is seen with all its serrations and irregularities, and then the star about to be occulted, whether large or small, coloured or white, apparently approaches it and instantly disappears at the point of contact. Under such conditions it never enters upon the limb of the Moon.

In geodetic work the phenomenon of false extension of the image of the heliotrope signal is the same as that for the false enlargement of the disc of the Sun, the Moon, *Jupiter*, or the image of a star. In the high Sierras of California, at 10,600 feet elevation, I have observed upon the minute images of heliotropes that did not measure one second of arc in diameter in the telescope, and were distant 120 to 160 miles to the north-west, where the wonderfully clear sky and the steady atmosphere after a

storm gave astonishing sharpness, steadiness, and nearness to all objects; and turning to the signals down to leeward the images of these heliotropes would range to thirty seconds of arc in diameter, and be remarkably diffuse, irregular, and unsteady. On a certain line of the triangulation in the coast range of mountains, where several mountain ridges and intervening valleys were crossed by the line of sight, and where the cold ocean air irruption, through the Karquines Strait, added tenfold confusion, the heliotrope image from Mount Diablo was like the waving flame from the stack of a smelting furnace, and sometimes exceeded sixty seconds of arc in diameter with its direction abnormal. When the air that the ray of light passed through became of uniform temperature the image was steady, small, and starlike, and its direction normal.

We meet with phenomena of similar character in observing upon all geodetic signals, especially in the less elevated regions; "poles" are only seen sharply and clearly defined when the atmosphere is supremely clear and still, and then at enormous distances. As a rule they are apparently broadened several times their normal width by tho unsteadiness of the atmosphere.

It is this unsteadiness of the atmosphere, *and this alone,* which presents to the observer the phenomena of the "black drop," "ligament," &c., in the transits of *Venus* and *Mercury*; and the "Baily's beads," &c., in total solar eclipses.

When the atmosphere is fairly clear and remarkably steady, so that there is little or no irradiation from the disc of *Jupiter*, and necessarily no unsteadiness in the appearance of the satellites, I have been able to distinguish with the naked eye two satellites as one, when they were near each other. I have made public record of such occurrences; and at one station in the mountains all the members of my party saw the phenomenon. Under similar conditions of atmospheric serenity, but with the advantage of greater elevation, one or more of the professors from the United States Naval Observatory, then in the mountains of Colorado to observe the total solar eclipse of 1878, saw three satellites of *Jupiter* with the unassisted eye, the fourth being behind the planet. When these favourable conditions exist the occultation of a satellite by the planet is very satisfactorily observed.

In years of experience upon the Pacific Coast of the United States in observing lunar transits, I learned to expect wild results when a spurious bright limb of the Moon was observed, the resulting longitude being affected as if the diameter of the Moon were too great. At times, when the vibration or undulation of the disc of the Moon was not rapid, the sharp limb could be observed even with a faint spurious outline beyond it. Within the last two months my party has had a case of spurious disc from excessive diffusiveness, with a predicted error in the resulting longitude that was verified.

In my observations of the last transit of *Venus*, at 5,691 feet above the sea and 1,600 feet above the arid Jornada del Muerte,

there were at one time occasional shiverings of the discs of the Sun and planet from slight tremulousness of the atmosphere, but the eye was not confused, as would have been the case if the discs had been ill-defined and unsteady by excessive vibration. In the first case the eye could and did select its opportunity for measurement. At other stations for the same transit the atmospheric disturbance distorted the appearance of the fine crescent of coronal light apparently surrounding part of the disc of *Venus* when the planet was partially off the Sun's limb; but at Cerro Roblero the steadiness of the atmosphere at the time of the last exhibition of this phase permitted us to see the long, thin, white crescent, as fine and sharp and regular as if cut by a graver, die away in excessive minuteness.

In conclusion, I may mention that I have been fortunate in my observations of the transits of *Venus* and of *Mercury* never to have had the exhibition of "ligament" or "black drop"; and in solar eclipses to have never seen "Baily's beads," &c. In my experience the occurrence of supreme steadiness of the atmosphere is very rare indeed, but has happened oftener at great elevations of mountain peaks, and the narrow crest-line of a mountain-range during the winter season of this coast.

The Jovian Evection. By E. Nevill.

In the year 1876, whilst discussing the observations of the Moon made at Greenwich and Washington during the years 1862–74, Professor Newcomb discovered a new inequality in the motion of the Moon in longitude.

This inequality was subsequently shown to arise from the disturbing action of the planet *Jupiter*, and to be the term in the perturbations produced by that planet which corresponds to the well-known *evection* due to the disturbing action of the Sun. Hence the name—the *Jovian Evection.*

In the *Memoirs* (vol. xxix., 1861) Sir G. Airy has given the results obtained by him from a discussion of the Greenwich lunar observations during the period 1750–1851, and among other results he has deduced the corrections to the adopted theory having for argument the sine and the cosine of the Moon's mean anomaly. He gives the value deduced for the coefficient of these terms for twenty-one consecutive periods of about nine years each. These coefficients are tabulated on pp. 12 and 14, under the heads—values of S and of T respectively.

From a discussion of these values Sir G. Airy deduces the existence of apparent inequalities in the longitude of the Moon of the form—

$$+ 0''\cdot47 \sin (\alpha + B)$$
$$- 0'''\cdot17 \cos (\alpha + B)$$
$$- 1'''\cdot12 \sin (\alpha - B)$$
$$+ 0'''\cdot37 \cos (\alpha - B)$$

where a denotes the Moon's mean anomaly, and B denotes the mean longitude of the ascending node of the orbit of the Moon.

 . The disturbing action of neither the Sun nor planets can give rise to inequalities of this form in the expression for the longitude of the Moon, and Sir G. Airy appears to have been unable to account for their existence, although convinced that they were real. Yet even at that period it might have been seen that terms of this form must be introduced through the effect of the ellipticity of the Earth, for it was known that through this cause a term was introduced into the expression for the Moon's longitude having for its argument the longitude of the Moon's node as measured from the true equinox. Under the form—

$$+ 6''{\cdot}6 \sin (u - y), \quad \text{or} \quad 6''{\cdot}6 \sin \text{B},$$

this term had been introduced into the tables on which Sir G. Airy had based his reductions; but as this term does not involve the mean longitude of the Moon in its argument it must have associated with it two companion inequalities with the arguments

$$(a + \text{B})$$
$$(a - \text{B})$$

with small coefficients of the same order as those found from observation by Sir G. Airy.

As the *Jovian Evection* differs in period very slightly from the *mean anomaly*, it must give rise to an apparent inequality in the value found from observation for the terms with the argument *sine mean anomaly* and *cosine mean anomaly*. Hence, from a discussion of the variations in the values of these coefficients, as given by Sir G. Airy under the headings S and T (pp. 12 and 14, *Memoirs*, vol. xxix., 1861), it should be possible to derive the value of the *Jovian Evection*.

Let

A denote the mean longitude of the perigee of the lunar orbit,

l_{iv} denote the mean longitude of the planet *Jupiter*,

then the argument of the *Jovian Evection* may be written in the form

$$2\,\theta_{iv} - a = a - 2(l_{iv} - \text{A}),$$

where the mean motion of

$$2(l_{iv} - \text{A})$$

differs from the mean motion of the Moon's ascending node by only the very small quantity

$$\kappa = -1^{\circ}{\cdot}32 \ (\text{T} - 1832{\cdot}0).$$

Hence the argument of the *Jovian Evection* can be written as

$$2\theta_{iv} - a = a - (\text{B} + \kappa).$$

It remains to deduce the exact value of the *Jovian Evection* and associated inequalities from a discussion of the values for the coefficients S and T of the terms with the argument $\sin a$

and cos a, derived by Sir G. Airy from the Greenwich lunar observations made between 1750 and 1851.

Suppose the complete expression for the Moon's true longitude to contain the terms

$$\delta v = + A_s \sin a + \overset{+}{B}_s \sin (a+B) + \overset{-}{B}_s \sin (a-B) + K_s \sin (a-[B+\kappa])$$
$$+ A_c \cos a + \overset{+}{B}_c \cos (a+B) + \overset{-}{B}_c \cos (a-B) + K_c \cos (a-[B+\kappa])$$

then

$$S = A_s + \{(\overset{-}{B}_s + \overset{+}{B}_s) + K_s \cos \kappa + K_c \sin \kappa\} \cos B$$
$$+ \{(\overset{-}{B}_c - \overset{+}{B}_c) - K_s \sin \kappa + K_c \cos \kappa\} \sin B$$

and

$$T = A_c - \{(\overset{-}{B}_s - \overset{+}{B}_s) + K_s \cos \kappa + K_c \sin \kappa\} \sin B$$
$$+ \{(\overset{-}{B}_c + \overset{+}{B}_c) - K_s \sin \kappa + K_c \cos \kappa\} \cos B.$$

For convenience, the mean value of S or $(-0\cdot364)$ has been subtracted from each separate value for S, and after applying to T Sir G. Airy's correction for the motion of anomaly

$$= -0\cdot496 - 0\cdot162 \times \text{number of group from } 1801\cdot5,$$

they have been reduced to the same unit as those of S or to a T.

There are thus obtained the following system of equations of condition :—

A_s	$\overset{+}{B}_s$	$\overset{-}{B}_s$	$\overset{+}{B}_c$	$\overset{-}{B}_c$	K_s	K_c	S
+1	−1	−1	0	0	+ ·19	− ·98	= + ·c82
+1	0	0	−1	+1	− 1·00	− ·09	= + ·106
+1	+1	+1	0	0	+ ·02	+ 1·00	= − ·005
+1	0	0	+1	−1	+ ·99	·12	= − ·120
+1	−1	−1	0	0	− ·20	− ·97	= + ·013
+1	0	0	−1	+1	− ·95	+ ·33	= + ·169
+1	+1	+1	0	0	+ ·42	+ ·91	= + ·063
+1	0	0	+1	−1	+ ·85	− ·53	= − ·027
+1	−1	−1	0	0	− ·62	− ·79	= + ·113
+1	0	0	−1	+1	− ·72	+ ·70	= + ·125
+1	+1	+1	0	0	+ ·77	+ ·64	= − ·139
+1	0	0	+1	−1	+ ·56	− ·83	= − ·150
+1	−1	−1	0	0	− ·89	− ·45	= − ·067
+1	0	0	−1	+1	− ·36	+ ·93	= − ·011
+1	+1	+1	0	0	+ ·97	+ ·26	= − ·049
+1	0	0	+1	−1	+ ·16	− ·99	= + ·062
+1	−1	−1	0	0	− 1·00	− ·05	= + ·091
+1	0	0	−1	+1	+ ·05	+ 1·00	= − ·123
+1	+1	+1	0	0	+ ·99	− ·16	= − ·203
+1	0	0	+1	−1	− ·26	− ·97	= + ·011
+1	−1	−1	0	0	− ·93	+ ·36	= + ·071

A_c	$\overset{+}{B_s}$	$\overset{-}{B_s}$	$\overset{+}{B_c}$	$\overset{-}{B_c}$	K_s	K_c	aT
+1	0	0	−1	−1	+ ·98	+ ·19	= − ·152
+1	+1	−1	0	0	+ ·09	−1·00	= + ·000
+1	0	0	+1	+1	−1·00	+ ·02	= + ·035
+1	−1	+1	0	0	+ ·12	+ ·99	= − ·100
+1	0	0	−1	−1	+ ·97	− ·23	= + ·037
+1	+1	−1	0	0	− ·33	− ·95	= + ·170
+1	0	0	+1	+1	− ·91	+ ·42	= + ·028
+1	−1	+1	0	0	+ ·53	+ ·85	= − ·047
+1	0	0	−1	−1	+ ·79	− ·62	= − ·006
+1	+1	−1	0	0	− ·70	− ·72	= + ·178
+1	0	0	+1	+1	− ·64	+ ·77	= + ·012
+1	−1	+1	0	0	+ ·83	+ ·56	= − ·192
+1	0	0	−1	−1	+ ·45	− ·89	= − ·000
+1	+1	−1	0	0	− ·93	− ·36	= + ·256
+1	0	0	+1	+1	− ·26	+ ·97	= + ·050
+1	−1	+1	0	0	+ ·99	+ ·16	= − ·158
+1	0	0	−1	−1	+ ·05	−1·00	= − ·109
+1	+1	−1	0	0	−1·00	+ ·05	= + ·097
+1	0	0	+1	+1	+ ·16	+ ·99	= − ·030
+1	−1	+1	0	0	+ ·97	− ·26	= − ·197
+1	0	0	−1	−1	− ·36	− ·93	= + ·124

These yield the following set of normal equations :—

A_s	A_c	$\overset{+}{B_s}$	$\overset{+}{B_c}$	$\overset{-}{B_s}$	$\overset{-}{B_c}$	K_s	K_c	
+21·00 +	·00 −	1·00 +	·00 −	1·00 +	·00 −	·98 −	·80	= + ·012
+ ·00 +	21·00 +	·00 −	1·00 +	·00 −	1·00 +	·80 −	·98	= − ·004
− 1·00 +	·00 +	21·00 +	·00 +	1·00 +	·00 +	·34 +	·26	= + ·759
+ ·00 −	1·00 +	·00 +	21·00 +	·00 +	1·00 −	·26 +	·34	= − ·289
− 1·00 +	·00 +	1·00 +	·00 +	21·00 +	·00 +	12·96 +	10·80	= − 2·031
+ ·00 −	1·00 +	·00 +	1·00 +	·00 +	21·00 −	10·80 +	12·96	= + ·691
− ·98 +	·80 +	·34 −	·26 +	12·96 −	10·80 +	21·00 +	·00	= − 2·378
− ·80 −	·98 +	·26 +	·34 +	10·80 +	12·96 +	·00 +	21·00	= − ·681

On solution these yield the following set of values for the eight unknowns :—

A_s = − ·0041   K_s = − ·1018 $\overset{+}{B_s}$ = + ·0393 $\overset{-}{B_s}$ = − ·0320

A_c = + ·0017   K_c = − ·0078 $\overset{+}{B_c}$ = − ·0141 $\overset{-}{B_c}$ = − ·0138

To reduce these to seconds of arc multiply the first pair by 7″, and the others by $7'' \times \frac{\pi}{2}$. They then become

$$A_s = -\overset{''}{\cdot}029 \qquad K_s = -\overset{''}{1}\cdot120 \qquad \overset{+}{B}_s = +\overset{''}{\cdot}432 \qquad \overset{-}{B}_s = -\overset{''}{\cdot}352$$

$$A_c = +\cdot012 \qquad K_c = -\cdot086 \qquad \overset{+}{B}_c = -\cdot155 \qquad \overset{-}{B}_c = -\cdot152$$

Hence the value of the *Jovian Evection* derived from Sir G. Airy's reduction of the Greenwich lunar observations for the period 1750–1851 is

$$\textit{Jovian Evection} = -1''\cdot120 \sin(2\theta_{iv} - a) - 0''\cdot086 \cos(2\theta_{iv} - a).$$

The supplementary terms are

$$= -0''\cdot352 \sin(a - B) - 0''\cdot152 \cos(a - B)$$
$$+ 0\cdot432 \sin(a + B) - 0\cdot155 \cos(a + B).$$

The values found by Sir G. Airy were

$$- 1''\cdot12 \sin(a - B) + 0''\cdot37 \cos(a - B)$$
$$+ 0\cdot47 \sin(a + B) - 0\cdot17 \cos(a + B).$$

Hence the first pair are reduced to about a third of the value found by Sir G. Airy and the sign of the cosine term is changed, whilst the second pair remain practically unaltered.

Put

$$a = 2(l_{iv} - A),$$

then as far as the same set of terms is concerned

$$\delta v = + \{K_s + A_s \cos a - A_c \sin a + \overset{-}{B}_s \cos \kappa - \overset{-}{B}_c \sin \kappa\} \sin(2\theta_{iv} - a)$$

$$+ \{\overset{+}{B}_s \cos \kappa + \overset{+}{B}_c \sin \kappa\} \sin(2\theta_{iv} - a + 2a)$$

$$+ \{K_c + A_s \sin a + A_c \cos a + \overset{-}{B}_s \sin \kappa + \overset{-}{B}_c \cos \kappa\} \cos(2\theta_{iv} - a)$$

$$- \{\overset{+}{B}_s \sin \kappa - \overset{+}{B}_c \cos \kappa\} \cos(2\theta_{iv} - a + 2a).$$

Hence these terms give rise to inequalities in the apparent value of the coefficient of the *Jovian Evection* of the form

$$\delta K_s = A_s \cos a - A_c \sin a + \overset{-}{B}_s \cos \kappa - \overset{-}{B}_c \sin \kappa$$

$$\delta K_c = A_s \sin a + A_c \cos a + \overset{-}{B}_s \sin \kappa + \overset{-}{B}_c \cos \kappa.$$

In determining from observation the apparent value of the coefficient of the *Jovian Evection* care is taken to eliminate the terms depending on the argument a, so that there only remain the terms depending on the argument κ, or

$$\delta K_s = \overset{-}{B}_s \cos \kappa - \overset{-}{B}_c \sin \kappa \qquad\qquad \delta K_c = \overset{-}{B}_s \sin \kappa - \overset{-}{B}_c \cos \kappa.$$

It remains to ascertain how far this inequality affects the values for the *Jovian Evection* which have been deduced from

the observations of late years. There are four such values, based on the comparison of Hansen's Tables with the observations for the periods : —

		Mean year
I.	1847–58	1853·0
II.	1862–74	1868·5
III.	1862–77	1870·0
IV.	1878–88	1883·5

Hence from the value of κ

I.	$\delta K_s = + \cdot86\ \bar{B}_s + \cdot52\bar{B}_c$	$\delta K_c = - \cdot52\ \bar{B}_s + \cdot86\ \bar{B}_c$
II.	$= + \cdot65 \quad + \cdot76$	$= - \cdot76 \quad + \cdot65$
III.	$= + \cdot62 \quad + \cdot79$	$= - \cdot79 \quad + \cdot62$
IV.	$= + \cdot33 \quad + \cdot95$	$= - \cdot95 \quad + \cdot33$

By employing the values of $\bar{B}_s . \bar{B}_c$, given by the preceding discussion of the Greenwich observations for the period 1750–1851, or

$$\bar{B}_s = -0\overset{''}{\cdot}35$$

$$\bar{B}_c = -0\cdot14,$$

there results the correction

I.	$\delta K_s = -0\overset{''}{\cdot}48$	$\delta K_c = +0\overset{''}{\cdot}06$
II.	$= -0\cdot35$	$= +0\cdot17$
III.	$= -0\cdot33$	$= +0\cdot20$
IV.	$= -0\cdot23$	$= +0\cdot29$

Hence the value of these coefficients, as deduced from the observations of these periods, will appear too large by the above quantities.

Before proceeding it is necessary to know the theoretical value for the coefficient of the *Jovian Evection.*

From a provisional investigation (*Monthly Notices*, April 1877, p. 358) the theoretical value of the main portion of this coefficient was determined to be

$$K_s = -1\overset{'''}{\cdot}163.$$

Besides the principal term there exist some secondary small ones, whose sum was determined by a provisional investigation to be (*Memoirs*, vol. xlviii. p. 403)

$$\delta K_s = -0\overset{''}{\cdot}105 \qquad \delta K_c = +0\overset{''}{\cdot}182.$$

A subsequent more extended investigation shows these values to be somewhat too great, and the true theoretical value of the *Jovian Evection* may be said to be

$$K_s = -1\overset{'''}{\cdot}186 \qquad K_c = +0\overset{''}{\cdot}106.$$

I I

Professor G. W. Hill, in his computation of the theoretical value of this term, makes the value to be

$$K_s = -0''\cdot903 \qquad\qquad K_c = +0''\cdot000.$$

("On certain Lunar Inequalities due to the Action of Jupiter," *Astronomical Papers, American Nautical Almanac,* vol. iii., part iv., p. 390, 1886.) But it has been shown that there is reason to believe that the method employed by Professor Hill is not complete, and yields only a portion of the complete value of the coefficient of this term (*Monthly Notices,* June 1886, p. 403).

By employing this value of the theoretical coefficient of the *Jovian Evection* there are obtained the following for the apparent value of the *Jovian Evection* at the different specified epochs :—

I. 1853·0	$K_s = -1''\cdot67$	$K_c = +0''\cdot17$
II. 1868·5	$= -1\cdot54$	$= +0\cdot28$
III. 1870·0	$= -1\cdot52$	$= +0\cdot31$
IV. 1883·5	$= -1\cdot42$	$= +0\cdot40$

From a discussion of the observations made at Greenwich during the twelve years 1847–58 Professor Newcomb found for the epoch 1853 the value

$$\text{I. } K_s = -1''\cdot66.$$

From a more elaborate discussion of the thirteen years' observations made at Washington and Greenwich during the period 1862–74, Professor Newcomb found for the epoch 1868·5 the value

$$\text{II. } K_s = -1''\cdot53$$

(*Monthly Notices,* June 1876, p. 360).

From a discussion of the observations made at Greenwich during the sixteen years 1862–77 it was shown that for the epoch 1870 the value of the term was

$$K_s = -1''\cdot41 \qquad\qquad K_c = +0''\cdot15.$$

But in this investigation ("On the Corrections required by Hansen's Tables de la Lune," *Memoirs,* vol. xlviii., 1885, p. 402) it was supposed that the motion of the lunar perigee adopted in the tables was sensibly correct. A more extensive comparison of Hansen's Tables with observation has shown that this is not the case, and that it is necessary to apply a correction to the tabular motion of the lunar perigee. This has rendered it necessary to revise the investigation, and on revision there is obtained for the epoch 1870 the values

$$\text{III. } K_s = -1''\cdot51 \qquad\qquad K_c = +0''\cdot28.$$

Last year, on the completion of the discussion of the results obtained by comparing Hansen's Tables with the Greenwich observations for the eleven years 1878–88, it was ascertained that the observations for this period yielded for the epoch 1883·5 the values

$$\text{IV. } K_s = -1'''\!\cdot 43 \qquad K_c = +0''\!\cdot 47.$$

A comparison of these results with those calculated above show how closely they agree :—

Epoch.	Observed.	Calculated.	Observed.	Calculated.
I. 1853·0	$K_s = -1''\!\cdot 66$	$-1''\!\cdot 67$	$K_c = \quad ''\!\!\ldots$	$+0''\!\cdot 17$
II. 1868·5	$= -1\cdot 55$	$-1\cdot 54$	$=\quad \ldots$	$+0\cdot 28$
III. 1870·0	$= -1\cdot 51$	$-1\cdot 52$	$= +0\cdot 28$	$+0\cdot 31$
IV. 1883·5	$= -1\cdot 43$	$-1\cdot 42$	$= +0\cdot 47$	$+0\cdot 40$

No comparison between observation and calculation could agree more closely, or appear more satisfactory. Yet this very agreement is a striking illustration of the difficulties inherent in the perfection of the theory of the Moon, and affords an example of the unexpected difficulties which have done so much to retard my work on the Theory of the Terms of Long Period in the motion of the Moon, and especially in that part where the theory has to be compared with observation.

For, complete and satisfactory as it looks, this agreement is entirely fortuitous, and means exactly nothing. This is for two reasons, both such as might easily escape attention.

First, because the small differences between the theory embodied in the lunar tables employed by Sir G. Airy and that forming the basis of Hansen's Tables rises into importance in the case of this particular inequality—the *Jovian Evection.*

Second, because, quite unexpectedly, further investigation shows that the values deduced by Professor Newcomb for the coefficient of his empirical term differ materially from the true value of the coefficient of the *Jovian Evection* deduced from the same data, though the arguments of the two are so nearly the same.

Considering the first of these reasons, it can be shown that when the observations are referred to Airy's tables there will appear to exist inequalities of the form

$$+0''\!\cdot 52 \sin (\alpha + B) + 0''\!\cdot 04 \cos (\alpha + B)$$
$$-0\cdot 52 \sin (\alpha - B) + 0\cdot 04 \cos (\alpha - B),$$

which will not appear when the same observations are referred to Hansen's Tables, though apparently both tables are alike in respect to terms of this kind.

For the effect of the ellipticity of the Earth on the motion of the Moon in longitude is taken into account by Sir G. Airy by introducing a term as an inequality in the true longitude,

whereas Professor Hansen introduces this term as an inequality of the mean longitude; but when introduced as by Sir G. Airy the principal term requires to be accompanied by a pair of smaller terms of the form

$$+0\overset{''}{\cdot}52 \sin (a+B)$$
$$-0\cdot52 \sin (a-B),$$

whereas no such terms are required when the principal term is introduced as by Professor Hansen. As Sir G. Airy has omitted these auxiliary terms from the tables used by him they will appear in the discussion of the observations in the form of small apparent inequalities in the coefficients of the terms depending on the argument mean anomaly; but no such inequalities will exist when the observations are referred to Hansen's Tables.

Again, in the lunar tables employed by Sir G. Airy there are no terms to take account of the effect of the motion of the plane of the ecliptic; in consequence, when the observations are referred to these tables, there will appear small inequalities in the coefficients of the terms depending on the mean anomaly of the form

$$+0\overset{''}{\cdot}04 \cos (a+B)$$
$$+0\cdot04 \cos (a-B).$$

But no such inequalities will appear when the same observations are referred to Hansen's Tables, because, though they contain no distinct terms to take into account the effect of the motion of the ecliptic, yet this is done by slightly modifying the constant portion of the argument depending on the longitude of the node.

It follows, therefore, that these terms—due to imperfections in Airy's tables—must be subtracted from those found in the previous investigation before the results can be used to correct the values of the coefficient of the *Jovian Evection* founded on observations referred to Hansen's Tables. Hence the value of the coefficients which must be employed are—

$$\overset{+}{B}_s = (+0\overset{''}{\cdot}43) - (+0\overset{''}{\cdot}52) = -0\overset{''}{\cdot}09 \pm 0\overset{''}{\cdot}12$$

$$\overset{+}{B}_c = (-0\cdot15) - (+0\cdot04) = -0\cdot19 \pm 0\cdot12$$

$$\overline{B}_s = (-0\cdot35) - (-0\cdot52) = +0\cdot17 \pm 0\cdot19$$

$$\overline{B}_c = (-0\cdot15) - (+0\cdot04) = -0\cdot19 \pm 0\cdot19$$

Considering the uncertainty which attaches to the values deduced from observation, it is doubtful if any of these quantities is entitled to be considered real.

The values obtained by Professor Newcomb are

From the Observations of 1847-58.   From the Observations of 1862-74.
$$-1''\cdot66 \qquad\qquad\qquad -1'''\cdot55$$

These are not really the values of the coefficient of the *Jovian Evection*, but of an empirical term differing slightly in epoch and period ; and though the difference is so small that it might be deemed immaterial, yet a recalculation from the same data, only using the true argument, showed that this was not the case. For the results obtained are

From the Observations of 1847–58.   From the Observations of 1862–74.

$$K_s = -1''38 \qquad\qquad K_s = -1''54$$
$$K_c = -0·16 \qquad\qquad K_c = +0·29$$

Thus, though the results derived from the observations of 1862–74 agree with those deduced by Professor Newcomb, yet this is not true of those obtained from the observation of the earlier period 1847–58.   The apparent coefficient of the *Jovian Evection* is more than a quarter of a second smaller.   A possible explanation of this discrepancy soon presented itself.

The comparison which has been made between Hansen's Tables and observation (*Memoirs*, 1885) shows that the tables require a correction of the form

$$B'\ \sin(\theta + \mu) + B''\ \cos(\theta + \mu),$$

and from this there arises an eighteen-year inequality in the apparent value of the coefficient of the *Jovian Evection*. As the period covered by each of these series of observations falls far short of eighteen years, it follows that the values for the coefficient of the *Jovian Evection* deduced from them will require correction for the effect of this inequality. The true values will be—

From the Observations of 1847–58.   From the Observations of 1862–74.

$$K_s = -1''38 + ·48\ B' - ·15\ B'' \qquad K_s = -1''54 + ·30\ B' + ·16\ B''$$
$$K_c = -0·16 + ·15\ B' + ·48\ B'' \qquad K_c = +0·29 - ·16\ B' + ·30\ B''$$

A discussion of the observations for the sixteen years 1862–1877 yields for the approximate values of these coefficients

$$B' = -0''59$$
$$B'' = +0·38$$

It is likely, taking into consideration the probable origin of this inequality, that these coefficients in turn are affected by small inequalities of long period, and that these values are only true of the epoch for which they are determined ; but for the present purpose they must be applied as they stand, excepting that, as Professor Newcomb has already applied to the observation for 1862–74 the correction

$$-0''·13 \sin(\theta + \mu),$$

for these observations, the value given above for B' must be diminished by this amount.

This correction reduces the preceding expressions to

From the Observations of 1847–58.	From the Observations of 1862–74.
$K_a = -1\cdot71$	$K_a = -1\cdot62$
$K_c = -0\cdot07$	$K_c = +0\cdot48$

Hence the real values of the *Jovian Evection* indicated by observation are somewhat greater than calculated by Professor Newcomb as the value of his empirical term.

The preceding investigation shows clearly that the observations indicate a value for the apparent coefficient of the *Jovian Evection* which is much greater than that resulting from theory, and render it certain that with it there is associated another inequality of some magnitude and of very similar period. It also establishes that, had Sir G. Airy been more strict in examining the results obtained by him from the reduction of the Greenwich lunar observations for the years 1750–1851, he might have discovered the existence of the *Jovian Evection* fully thirty years ago.

Both of these conclusions suggest inquiries of some interest in the theory of the motion of the Moon.

1890 *February* 20.

On the Orbit of δ *Cygni*. By J. E. Gore.

The following elements of δ *Cygni* I computed some three years ago, but as they give the distance at the epoch of Sir W. Herschel's measure in 1783 somewhat too large, I did not publish them. As, however, they represent all the measures of position-angle fairly well, I now give them for what they are worth.

Provisional Elements of δ Cygni.

$P = 376\cdot659$ years	$\Omega = 98°\ 40'$
$T = 1914\cdot16$	$\lambda = 175°\ 7'$
$e = 0\cdot327$	$a = 2''\cdot39$
$i = 41°\ 26'$	$\mu = -0°\cdot9557$

The following is a comparison between the recorded measures and the positions computed from the above elements. The observed position-angles have been corrected for the effect of precession to 1880·0 :—

Epoch.	Observer.	θ_o	θ_c	$\theta_o - \theta_c$	ρ_o	ρ_c	$\rho_o - \rho_c$
1783·72	Sir W. Herschel	70°·98	70°·32	+0°·66	...	2''·72	...
1826·55	Struve	40·2	40·75	−0·55	1·91	2·04	−0·13
1828·80	„	36·5	38·7	−2·2	1·91	2·00	−0·09
1831·73	„	36·4	35·8	+0·6	1·57	1·95	−0·38

Epoch.	Observer.	θ_0	θ_c	$\theta_0 - \theta_c$	ρ_4	ρ_0	$\rho_0 - \rho_0$
		°	°	°	″	″	″
1832·72	{ Sir J. Herschel & South }	32·3	34·7	− 2·4	1·5	1·93	− 0·43
1833·81	Struve	35·9	33·7	+ 2·2	1·70	1·91	− 0·21
1835·66	,,	34·3	31·7	+ 2·6	1·68	1·89	− 0·21
1836·52	,,	31·6	30·75	+ 0·85	1·80	1·87	− 0·07
1837·27	Mädler	31·0	29·9	+ 1·1	1·61	1·87	− 0·21
1837·78	Smyth	30·6	29·3	+ 1·3	1·5	1·87	− 0·37
1839·66	Dawes	27·1	27·2	− 0·1	1·5	1·83	− 0·33
1840·67	,,	24·8	26·1	− 1·3	...	1·81	...
1841·50	Mädler	26·3	25·1	+ 1·2	...	1·80	...
1841·89	Dawes	23·4	24·7	− 1·3	1·66	1·80	− 0·14
1841·94	Kaiser	25·4	24·6	+ 0·8	1·72	1·79	− 0·07
1842·56	Smyth	25·3	23·7	+ 1·6	1·8	1·78	+ 0·02
1842·77	Mädler	21·3	23·5	− 2·2	1·46	1·78	− 0·32
1843·12	Kaiser	25·5	23·1	+ 2·4	1·71	1·78	− 0·07
1843·45	Mädler	22·4	22·7	− 0·3	(1·28)	1·77	(− 0·49)
1844·36	,,	23·7	21·6	+ 2·1	1·47	1·75	− 0·28
1844·78	O. Struve	19·4	21·1	− 1·7	1·68	1·75	− 0·07
1845·65	Mädler	21·7	20·0	+ 1·7	1·32	1·74	− 0·42
1846·35	,,	20·0	19·1	+ 0·9	1·33	1·74	− 0·41
1847·18	,,	18·8	18·0	+ 0·8	...	1·73	...
1847·39	Dawes	16·5	17·7	− 1·2	...	1·73	...
1848·75	,,	14·3	15·9	− 1·6	1·76	1·72	+ 0·04
1851·51	,,	11·3	12·2	− 0·9	1·65	1·66	− 0·01
1851·68	Fletcher	10·1	12·0	− 1·9	1·75	1·66	+ 0·09
1852·44	Mädler	13·6	10·9	+ 2·7	(1·19)	1·64	(− 0·45)
1852·69	Smyth	14·5	10·5	+ 4·0	1·5	1·64	− 0·14
1852·70	O. Struve	8·1	10·5	− 2·4	1·51	1·64	− 0·13
1852·74	Dawes	10·5	10·5	0·0	1·68	1·64	+ 0·04
1853·73	,,	7·1	9·1	− 2·0	1·76	1·64	+ 0·12
1854·56	,,	4·1	7·9	− 3·8	1·68	1·64	+ 0·04
1854·76	Morton	(0·8)	7·6	(− 6·8)	(1·11)	1·64	(− 0·53)
1855·74	,,	(0·2)	6·2	(− 6·0)	(1·27)	1·62	(− 0·35)
1856·84	Secchi	3·0	4·6	− 1·6	1·41	1·61	− 0·20
1858·71	O. Struve	3·1	1·8	+ 1·3	1·65	1·60	+ 0·05
1859·58	Dawes	357·6	0·5	− 2·9	1·67	1·59	+ 0·08
1862·75	Dembowski	355·3	355·6	− 0·3	...	1·57	...
1863·61	,,	355·4	354·2	+ 1·2	1·58	1·57	+ 0·01
1863·74	O. Struve	353·7	354·0	− 0·3	1·60	1·57	+ 0·03

Epoch.	Observer.	θ_o	θ_c	$\theta_o - \theta_c$	ρ_o	ρ_c	$\rho_o - \rho_c$
1864·72	Dembowski	351·2	352·56	−1·36	1·68	1·56	+0·12
1864·74	Engelmann	354·3	352·53	+1·77	(2·30)	1·56	(+0·74)
1865·38	Dawes	349·5	351·4	−1·9	1·67	1·55	+0·12
1865·43	Knott	348·9	351·3	−2·4	1·70	1·55	+0·15
1865·64	Dembowski	350·4	351·0	−0·6	1·55	1·55	0·0
1866·08	Secchi	350·3	350·3	0·0	1·23	1·55	−0·32
1866·68	Knott	348·2	349·4	−1·2	1·70	1·55	+0·15
1867·06	Dembowski	348·8	348·8	0·0	1·51	1·55	−0·04
1868·61	,,	347·1	345·9	+1·2	1·56	1·54	+0·02
1868·69	Brünnow	348·9	345·8	+3·1	1·52	1·54	−0·02
1869·60	Dembowski	346·3	344·7	+1·6	1·58	1·54	+0·04
1870·56	,,	343·3	343·1	+0·2	1·72	1·54	+0·18
1870·85	Dunér	343·6	342·65	+0·95	1·53	1·54	−0·01
1871·50	Dembowski	342·1	341·6	+0·5	1·59	1·54	+0·05
1871·74	Knott	337·8	341·2	−3·4	1·69	1·54	+0·15
1872·60	Dembowski	339·2	339·8	−0·6	1·51	1·53	−0·02
1872·67	Knott	(330·1)	339·7	(−9·6)	1·69	1·53	+0·16
1872·78	Wilson & Seabroke	336·7	339·5	−2·8	...	1·53	...
1872·81	O. Struve	341·6	339·5	+2·1	1·47	1·53	−0·06
1873·56	Dembowski	336·2	338·2	−2·0	1·61	1·53	+0·08
1874·62	,,	336·3	336·5	−0·2	1·55	1·53	+0·02
1874·70	Wilson & Seabroke	339·1	336·4	+2·7	...	1·53	...
1875·58	Dembowski	333·7	334·9	−1·2	1·58	1·53	+0·05
1875·69	Dunér	336·5	334·7	+1·8	1·52	1·53	−0·01
1875·10	Wilson & Seabroke	335·8	334·7	+1·1	...	1·53	...
1878·65	Dembowski	330·12	332·36	−2·24	1·632	1·53	+0·102
1878·65	Burnham	333·1	329·8	+3·3	1·40	1·53	−0·13
1882·66	Frisby	317·7	323·3	−5·6	1·60	1·54	+0·06
1882·72	Hall	328·3	323·2	+5·1	1·53	1·54	−0·01
1882·84	Engelmann	321·46	323·0	−1·54	1·752	1·54	+0·212
1883·82	,,	321·50	321·4	+0·1	1·791	1·55	+0·241
1883·62	Perrotin	322·52	321·7	+0·82	1·667	1·55	+0·117
1883·77	Küstner	320·6	321·5	−0·9	1·75	1·55	+0·20
1885·52	Tarrant	317·83	318·7	−0·87	1·66	1·55	+0·11
1885·90	Engelmann	318·99	318·07	+0·92	1·723	1·553	+0·170
1886·435	Tarrant	318·3	317·2	+1·1	1·71	1·55	+0·16
					["too large"]		
1886·65	J. J. M. Perry	315·0	316·9	−1·9	1·6	1·55	+0·05
1887·50	Tarrant	315·92	315·54	+0·38	...	1·56	...

A Revolving Diagonal with Combined Total Reflection and Solar Prism. By William Schooling.

A revolving diagonal enables eye-pieces to be brought into position in rapid succession, just as a nose-piece on a microscope makes it possible to change objectives quickly and easily. It consists of a tube, screwed at each end, for fixing to the telescope, and containing a prism, which acts as a total reflection, or a first surface, prism, according to the end which is presented to the source of light, the tube having holes cut in two places to allow of the passage of the reflected light.

A hollow cube, pierced on all sides, revolves round this tube, and into four sides of the cube are screwed, at right angles to the tube containing the prism, four sockets for receiving the eye-pieces.

By revolving the cube, eye-pieces of various powers can be brought into position quickly and easily, a small stop indicating when the correct place is reached.

The eye-pieces being screwed into short tubes, or adapters, which slide into the sockets, may be focussed by pushing the adapters more or less into the sockets, and as eye-pieces of various powers are successively brought into position, each is in focus without any fresh use of the focussing screw of the telescope.

I believe the revolving arrangement to be a convenience, which has not been made before.
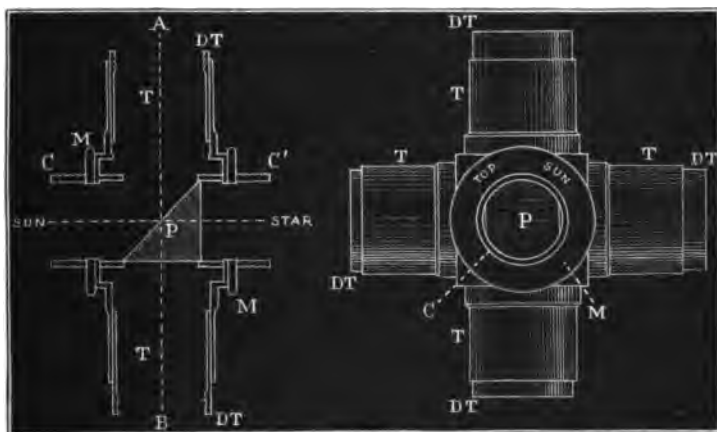
P. is a prism fixed in a tube ending at

C. C'. in collars screwed for attaching to telescope.

M. M. are discs with milled edge fixed to the tube, enabling the tube and prism to be held while the eye-pieces are rotated.

T. T. T. T. are tubes attached to a hollow cube that rotates round the tube that holds the prism.

DT. DT. are draw tubes or

DT. DT. adapters holding the eye-pieces and sliding in the tubes T.

When the Sun is to be observed the diagonal is attached to the telescope by the collar C, and the course of the rays is Sun P.A., and by rotating the cube each of the tubes T can be successively brought into the position A. When a star is to be observed the diagonal is attached by C′, and the course of the rays is Star P.B., and, again, any eye-piece is brought into position by rotating.

Notes on Reflecting Telescopes and the Making of Large Discs of Glass for them. By A. A. Common, F.R.S.

In May 1884 I read a "Note on a Method of Reducing the Friction of the Polar Axis of a Large Telescope." In this note I gave a new possible form of reflecting telescope. M. Loewy must have been working at the same subject at the same time, for he gives in the June number of the *Bulletin Astronomique* the identical arrangement, carrying it further and developing the complete Coudé reflecting telescope. In thinking over the best kind of telescope to erect in a situation that is much better than my present observatory, but which is unfortunately much exposed to wind, I have been again disposed to think that a modification of the arrangement of the Coudé telescope as suggested by M. Loewy or of the arrangement suggested by myself—for it is a modification of both—might be used with good effect. This combination, as I have since found, is not new, having been described by a Mr. Benjamin Martin about 150 years ago, according to Dr. Dick, who illustrates it on pp. 288 of his *Practical Astronomer.*

Shortly, it may be described as exactly what M. Loewy describes in the *Bulletin Astronomique* as the complete Coudé reflector, but without the front or outer large plane mirror; that is, a plane mirror pierced with a hole of proper size, placed in front of the concave at a distance somewhat less than its focal length. Optically the arrangement is as given in fig. 1.

Fig. 1
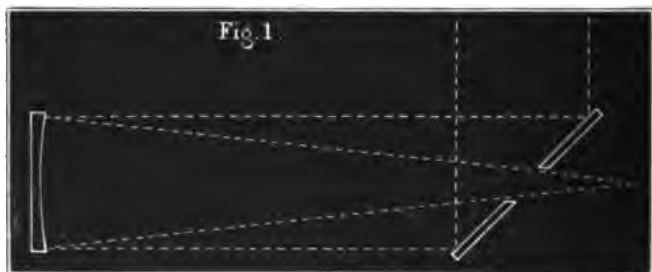
There are two ways in which such an optical combination may be used equatoreally: the first, to swing the whole on a polar axis, so that the whole can be moved in declination to any

required point, the polar axis giving the required motion in the other direction. The other to mount the tube carrying the concave mirror rigidly at right angles to the polar axis and to give a power of rotation to the plane mirror in a plane at right angles to the axis of the concave mirror. The last way seems to be in some respects the best, as it keeps the concave mirror in a better position as regards the supports and adjustments. In considering the relative advantages of the Coudé telescope as described by M. Loewy, and such a form as this, it must at once be admitted that there is a considerable sacrifice of the many favourable points of the former, but there is some gain—the most important one, the use of only two reflecting surfaces in place of three, and the consequent greater ease and permanence of adjustment. One of the points sacrificed is the comfort of the observer, but here the loss is not so great as it seems at the first glance, for, by making the equatoreal so that the polar axis is near the plane mirror, counterposing, if necessary, the amount of movement of the eye-end may be made small. The worst feature of such an arrangement is that the telescope must be reversed on the meridian; this is, no doubt, for much work a very serious objection. When I say it must be reversed, I speak with some slight hesitation, as it might be found that the concave mirror could be supported, so that when it passed the vertical it would not perceptibly shift. This involves a rigidity of mounting that would be more or less difficult to obtain. The other way of mounting this form of telescope is not open to this objection, and it retains the relative adjustments of the two mirrors always.
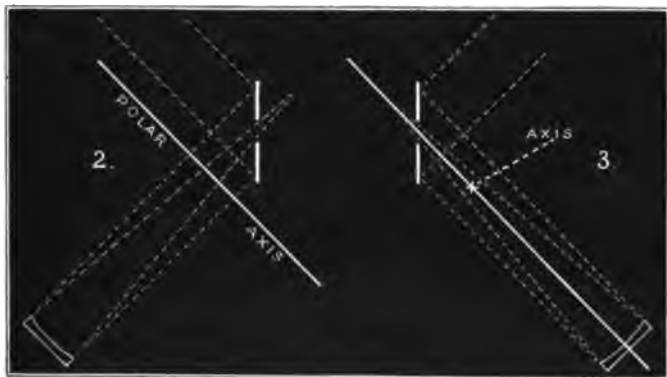

Fig. 2 gives the plan of mounting where the tube is fixed to the polar axis, and the plane mirror rotates. Fig. 3 shows the tube and the plane mirror mounted rigidly together, swinging on the polar axis in declination.

One of the very great advantages is that there will not be any diffraction rays, as in the Newtonian, caused by the supports

of the small mirror. The loss of light would, of course, be the same as in the Newtonian.

The large discs of glass that can be made into mirrors are difficult to obtain, as there seems to be a limit that the makers can deal with at one melting. I suggested some time since to one or two glass makers that it would be possible to build up the discs by having a top and bottom disc of a moderate thickness, say for an 8-foot disc of about 2″ thick, separating these discs by a series of, say, four or five cross strips of glass of a similar thickness, not quite touching, placed crossing each other; then by using a powder of an easily fusible glass, fluxing the whole together in the annealing furnace. This seems to be worth trying, though I cannot say whether it would succeed. I offer the suggestion, as it could be tried by using a thickness of glass that the manufacturers seem to be able to produce easily.

1890 *May* 6.

Observations of Mimas, 1890. By A. A. Common, F.R.S.

On the few occasions when the weather has permitted observation, *Mimas* has been looked for with the 5-foot reflector. The following observations were made :—

	d	h	m	
1890 March	17	12	30	*Mimas* just well past W. elongation.
		12	37	Well past.
		12	45	„ „
April	20	9	30	*Mimas* coming up to W. elongation.
		10	10	At W. elongation.
	29	10	30	*Mimas* in conjunction with E. end of ring; observation difficult, definition bad. (A. Taylor.)

Observations of the Planets Victoria and Sappho, made with the Cambridge Transit Circle in the Year 1889.

(*Communicated by Prof. J. C. Adams.*)

Victoria.

Date of Obs. 1889.	True Apparent R.A.	True Apparent N.P.D.	Date of Obs. 1889.	True Apparent R.A.	True Apparent N.P.D.
	h m s	° ′ ″		h m s	c ′ ″
June 25	19 59 11·66	96 38 58·67	July 30	19 32 47·58	94 41 2·98
26	19 58 40·32	96 31 26·34	Aug. 3	19 30 12·94	94 47 1·15
27	19 58 7·25	96 24 8·77	5	19 29 5·25	94 51 12·14
July 5	19 52 49·19	95 33 38·07	6	19 28 34·09	94 53 34·07
11	19 48 5·69	95 6 3·99	15	19 25 17·99	95 21 47·04
18	19 42 13·50	94 45 51·51	17	19 24 56·87	95 29 26 01
23	19 38 4·71	94 39 23 73	29	19 25 54·51	96 20 51·07

Sappho.

Date of Obs. 1889.	True Apparent R.A.			True Apparent N.P.D.			Date of Obs. 1889.	True Apparent R.A.			True Apparent N.P.D.		
	h	m	s	°	′	″		h	m	s	°	′	″
Sept. 10	1	11	25·45	72	7	31·78	Oct. 9	0	55	29·18	76	43	9·62
16	1	9	34·97	72	43	0·59	10	0	54	47·30	76	56	2·81
17	1	9	10·38	72	50	13·58	12	0	53	24·71	77	22	6·24
20	1	7	46·89	73	13	50·42	14	0	52	4·47	77	48	17·10
25	1	4	59·62	73	59	52·97	21	0	47	50·66	79	19	29·02
Oct. 3	0	59	42·22	75	28	20·63	24	0	46	19·71	79	57	16·93
7	0	56	53·28	76	17	40·15	25	0	45	52·15	80	9	34·61
8	0	56	11·10	76	30	21·46	31	0	43	42·17	81	19	19·43

N.B.—The above planets' places are not corrected either for aberration or parallax.

Mean Right Ascensions and Mean North Polar Distances for January 1, 1889, *of Comparison Stars with the Planet Victoria. Observed with the Cambridge Transit Circle.*

Reference Number of Star.	D.M.	Number of Obs.	Mean R.A. Jan. 1, 1889.			Mean N.P.D. Jan. 1, 1889.		
	°		h	m	s	°	′	″
1	−6·5151	3	19	21	25·30	95	57	22·24
2	−6·5158	3	19	23	2·68	96	24	2·15
3	−5·4985	3	19	24	6·30	95	9	7·97
4	−5·4989	4	19	25	17·96	95	54	13·74
5	−5·4992	5	19	25	40·41	95	21	3·88
6	−5·5006	5	19	27	50·56	94	58	50·71
7	−4·4843	3	19	28	37·76	94	41	25·08
8	−4·4846	3	19	29	20·70	94	33	6·70
9	−5·5021	3	19	30	41·23	95	1	3·72
10	−4·4855	3	19	30	53·49	94	32	44·86
11	−3·4649	2	19	31	22·06	93	43	19·99
12	−4·4861	4	19	31	54·02	94	53	41·71
13	−5·5036	3	19	34	26·95	95	42	8·41
14	−4·4877	5	19	34	53·56	94	17	22·63
15	−4·4883	7	19	35	56·07	94	32	51·00
16	−4·4903	4	19	39	23·76	94	47	23·88
17	−4·4916	5	19	40	59·51	93	56	1·74
18	−5·5060	2	19	41	53·43	95	30	24·59
19	−4·4926	8	19	43	4·53	94	46	19·44
20	−4·4936	2	19	43	44·00	94	48	25·93
21	−5·5075	2	19	44	56·11	94	58	28·26
22	−4·4960	4	19	47	27·31	94	51	33·76

Reference Number of Star.	D.M.	Number of Obs.	Mean R.A. Jan. 1, 1889.	Mean N.P.D. Jan. 1, 1889.
	°		h m s	° ′ ″
23	− 5–5099	4	19 48 22·41	95 20 1 33
24	− 5–5120	4	19 51 25·88	94 58 55·54
25	− 5–5124	4	19 52 3·61	95 29 2 07
26	− 6–5320	4	19 52 18·20	96 38 57·47
27	− 4–4984	2	19 52 38·11	94 39 18·45
28	− 4–4992	3	19 54 57 35	94 36 53·66
29	− 6–5339	3	19 55 39·86	96 40 50·12
30	− 5–5138	3	19 56 17·67	95 17 50·29
31	− 8–5205	3	19 57 4·81	98 0 14·76
32	− 5–5144	3	19 57 21·75	94 56 29·82
33	− 6–5360	4	19 59 23·84	96 53 58·41
34	− 4–5016	2	20 0 44·92	94 44 5·62
35	− 7–5169	5	20 0 46·73	97 19 56·40
36	− 8–5237	2	20 1 3·74	98 30 0·13
37	− 9–5382	7	20 5 8·99	99 10 12·87

Observations of Stars as Culminators.

	− 8–4887	20	19 6 39·46	98 7 27·71
	− 5–4936	20	19 14 37·34	95 37 22·16
	− 6–5451	9	20 14 31·50	96 42 29·36
	− 3–4888	8	20 19 55·09	93 9 36·40

Mean Right Ascensions and Mean North Polar Distances for January 1, 1889, of Comparison Stars with the Planet Sappho. Observed with the Cambridge Transit Circle.

Reference Number of Star.	D.M.	Number of Obs.	Mean R.A. Jan. 1, 1889.	Mean N.P.D. Jan. 1, 1889.
	°		h m s	° ′ ″
	+ 8–101	1	0 37 16·297	81 35 28·90
	+ 7–104	1	0 39 55·566	82 45 45·00
1	+ 8–110	4	0 42 25·234	81 23 2·60
2	+ 9–090	2	0 42 31·14	80 20 50·06
3	+ 11–102	3	0 44 24 38	78 46 24·18
4	+ 9–097	6	0 44 46·70	80 11 35·64
5	+ 11–106	3	0 45 46·15	77 49 7·08
6	+ 9–099	2	0 46 20·45	80 0 7·38
7	+ 12–104	3	0 46 40 08	76 57 15·41
8	+ 9–101	3	0 47 0·60	80 47 55·59
9	+ 10–105	5	0 48 2·91	79 28 47·68

Reference Number of Star.	D.M.	Number of Obs.	Mean R.A. Jan. 1, 1889.	Mean N P.D. Jan. 1, 1889.
	°		h m s	° ′ ″
10	+ 12-108	4	0 49 12·00	77 45 14·94
11	+ 13-127	3	0 50 19·74	76 38 58·09
12	+ 11-118	2	0 50 40·48	77 53 14·85
13	+ 13-130	2	0 50 52·32	75 49 29·80
14	+ 9-110	3	0 50 59·24	80 35 5·00
15	+ 11-120	3	0 51 32·89	78 10 13·79
16	+ 12-119	4	0 52 5·06	76 54 15·67
17	+ 13-143	3	0 53 53·74	75 59 21·22
18	+ 10-115	2	0 55 25·64	79 25 0·55
19	+ 11-135	4	0 55 32·85	78 41 9·56
20	+ 13-150	4	0 56 43·55	76 20 41·99
21	+ 15-154	3	0 57 9 68	74 27 33·10
22	+ 12-126	2	0 57 16·42	77 32 49·69
23	+ 13-155	2	0 58 0·67	76 39 32·41
24	+ 14-163	6	0 59 13·77	75 39 4·30
25	+ 14-168	5	0 59 57·09	75 36 44·07
26	+ 15-159	2	1 0 29·70	74 16 49·22
27	+ 15-164	6	1 1 59·67	74 23 45·27
28	+ 16-116	3	1 2 2·15	73 10 49·31
29	+ 16-119	4	1 2 34·97	72 56 19·70
30	+ 14-175	4	1 4 18·25	74 55 1·03
31	+ 17-166	3	1 5 3·88	72 11 53·84
32	+ 16-123	3	1 5 10·32	73 48 47·94
33	+ 13-175	3	1 5· 24·12	75 53 54·53
34	+ 15-175	3	1 6 55·81	73 49 31·44
35	+ 15-177	7	1 8 13·81	74 27 14·82
36	+ 16-129	6	1 10 15·81	72 57 7·28
37	+ 15-185	5	1 11 34·48	74 13 52·08
38	+ 17-183	8	1 12 26·08	72 0 28·74

Observations of Stars as Culminators.

	+ 10-065	16	0 31 32·027	79 10 28·13
	+ 15-106	16	0 37 4·282	73 56 36·79
	+ 10-171	14	1 17 2·193	79 12 46·61
	+ 16-154	14	1 22 25·994	73 29 43·95

Observations of Comet a 1890 (Brooks), made at the Royal Observatory, Greenwich.

(Communicated by the Astronomer Royal.)

The observations were made with the East or Sheepshanks equatoreal, aperture 6·7 inches, by taking transits over two cross wires at right angles to each other, and each inclined 45° to the parallel of declination.

Comet a 1890 (Brooks).

Greenwich Mean Solar Time.	Observer.	☾—* R.A.	Corr. for Refraction.	☾—* N.P.D.	Corr. for Refraction.	No. of Comp.	Apparent R.A.	Log. factor of Parallax.	Apparent N.P.D.	Log. Factor of Parallax.	Comp. Star.
1890. d h m s		m s	s	′ ″	″		h m s		° ′ ″		
April 16 15 2 55	H.	−1 28·42	0·0	− 8 8·8	−·04	3	21 9 19·40	9·5530	70 36 42·6	0·7605	a
16 15 7 24	...	−0 45·25	0·0	+ 0 15·5	0·0	5	21 9 21·52	9·5496	70 36 39·4	0·7482	b
29 13 17 7	L.	+0 40 25	0·0	− 8 34·1	−·04	4	21 1 33·91	9·6132	61 32 31·8	0·7400	c
13 39 41	...	+0 45·00	0·0	+11 17·9	+·06	6	21 1 33·19	9·6022	61 32 6·7	0·7202	d
13 53 17	...	+3 17·75	0·0	+ 4 19·9	+·02	2	21 1 32·79	9·5922	61 31 34·4	0·7065	e
13 53 17	...	+2 43·75	0·0	+10 48·4	+·05	2	21 1 31·99	9·5922	61 31 35·8	0·7065	f
30 13 24 12	H.	−0 20·59	0·0	+ 0 9·2	0·0	6	...	9·6122	...	0·7259	g
13 37 52	...	+3 31·83	0·0	− 3 47·2	−·02	2	21 0 39·22	9·6032	60 44 26·6	0·7108	h
13 50 4	...	−3 28·33	0·0	+ 0 35·0	0·0	2	...	9·5964	...	0·7013	i
May 1 13 20 45	A.D.	+0 42·83	0·0	+ 0 4·5	0·0	6	...	9·6136	...	0·7185	j
1 13 37 35	...	+1 34·33	0·0	+11 35·7	+·04	3	20 59 31·33	9·6028	59 56 47·2	0·7008	k

Assumed Mean Places of Comparison Stars.

	Star's Name		R.A. 1890·0	N.P.D. 1890·0	Authority.
			h m s	° ′ ″	
a	W.B. (2) xxi. 207	...	21 10 48·52	70 44 37·3	Lamont
b	W.B. (2) xxi. 185	...	21 10 7·44	70 36 10·0	,,
c	Lalande 40906	...	21 0 53·86	61 40 50·5	Lalande
d	W.B. (2) xx. 1834	...	21 0 48·39	61 20 32·3	Weisse's Bessel (2)
e	W.B. (2) xx. 1765	...	20 58 15·22	61 26 58·4	,,
f	W.B. (2) xx. 1780	...	20 58 48·43	61 20 31·0	,,
g	B.D. + 29°.4304...	...	21 0 55	60 45	B.D., vol. iv.
h	Lalande 40763	...	20 57 7·52	60 47 57·9	Lalande
i	B.D. + 29°.4326	...	21 4 3	60 43	B.D., vol. iv.
j	B.D. + 29°.4292	...	20 58 52	59 57	,,
k	W.B. (2) xx. 1761	...	20 57 57·12	59 44 55·0	Weisse's Bessel (2)

Notes.

May 1. Comet merely a patch of light; sky hazy.

The observations are corrected for refraction, but not for parallax.
The initials A. D., L., and H. are those of Mr. Downing, Mr. Lewis, and Mr. Hollis respectively.

Royal Observatory, Greenwich:
   1890 May 7.

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Catalogue of 918 *Radiant Points of Shooting Stars observed at Bristol.* By William F. Denning.

My observations of shooting stars date from the great display of Leonids in November 1866, though for several years they were merely pursued in a desultory way. In 1870 and at subsequent periods I furnished notes to the British Association Committee on Luminous Meteors, and thereafter adopted a more systematic plan of recording the paths of shooting stars. It was not, however, before the spring of 1876 that I entered upon any lengthy and regular observations with the design of ascertaining the radiant points of the minor showers generally. From 1876 until the present time I have been more or less engaged in gathering materials, though during the years from 1880 to 1883 inclusive I effected little, my leisure being applied to telescopic observations. The following summary shows the number of meteor paths which were registered in each year or, when the results were few, in a series of years :—

Year.			Year.		
1873–4	185	meteors.	1880–4	492	meteors.
1876	786	„	1885	1109	„
1877	1929	„	1886	1162	„
1878	501	„	1887	1809	.,
1879	663	„	1888–9	541	„

Total, 1873–89, 9177 meteors.

Several thousands were seen, in addition to these, either during habitual watches or casually ; but many of them belonged to showers which were already sufficiently determined, or were not observed with a degree of accuracy entitling them to record.

Below I give a table exhibiting the time spent in observation in each month, the number of meteors seen and registered, the horary rate of their apparitions, and the number of radiant points derived from them :—

Month.	Hours of Obv.	Meteors Seen.	Meteors Registered.	Horary Rate.	Number of Radiants.
January	58	346	300	6·5	34
February	28	128	119	4·9	11
March	29¾	178	164	6·6	19
April	96¼	580	510	6 6	63
May	58¼	281	274	5·2	25
June	64¼	292	260	4·9	25
July	157¼	1545	1208	11·3	129
August	232¼	3412*	1751	11·3†	178
September	154⅓	1391	1162	10·3	121
October	174¾	1751	1480	11·8	127
November	140¼	1351	1244	11·3	114
December	104¼	828	705	8 9	72
Total	1297¾	12083	9177	8·3	918

* Of these 1118 were Perseids.   † Perseids omitted.

It will be observed from this table that the bulk of my observations have been conducted in the last half of the year.

The 918 radiant points do not all represent different systems, for many of the most active streams, such as the Lyrids, Perseids, and Leonids, arrested notice in several years, and fresh determinations were made at each recurrence. It is impossible to say how many separate streams are implicated in the 918 positions given in the catalogue, owing to the fact that the visible durations of the great majority of them are not definitely known.

My plan of working may be briefly described as follows :— All the observations were made in the open air and from the garden adjoining the house. Attention was almost invariably given to the eastern sky. In mild weather I sat in a chair with the back inclined at a suitable angle; but on cold, frosty nights I found it expedient to maintain a standing posture, and sometimes to pace to and fro, always, however, keeping the eyes directed towards the firmament in quest of meteors.

Soon after I became regularly occupied in these observations I recognised the utility of adopting some means to aid the eye in fixing the precise *directions* of the apparent paths of meteors. I found that, while noting the position of the beginning and end points of a flight, a feeling of uncertainty would arise as to the observed slope of path. Meteors are usually so quick in their motions, and so rarely appear exactly in that place towards which the observer happens to be looking at the instant, that they only permit very hurried, and often imperfect, views, so that, when attributing definite positions, he becomes conscious that his estimate is, to some extent, doubtful, especially so in cases where the meteors fall in a comparatively bare region of the sky. Moreover, the observer's eye, in retracing and assigning the path-directions relatively to the stars, has a tendency to inaccurate estimation, and becomes, therefore, an untrustworthy guide, for these natural impressions of direction sometimes differ materially from those obtained by the projection of a perfectly straight wand upon the meteor's courses. I therefore found it essential to rely upon the latter contrivance as a help and corrective to the eye in ascribing the lines of flight. When a meteor was seen the wand was immediately projected upon its track, and the position quickly noted and reproduced on an 18-inch celestial globe. The time, magnitude, appearance, beginning-point, and probable radiant were then written down, and other details left to be filled in on the following day, when all the paths were carefully compared and their provisional radiants derived. During the actual progress of these observations it is necessary to utilise time to the utmost degree, for, unless the observer exercises celerity in registering the flights, he will, during the short intervals his attention is diverted from the sky, lose many important meteors. In any case some must escape his vigilance ; but the number will not be large on

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ordinary nights if he does the work of charting as rapidly as is consistent with precision.

My observations were almost equally distributed between the morning and evening hours, and were usually made between the third and first quarters of the moon. (In the presence of moonlight meteors are commonly rare, and one tires of watching for them. There is, perhaps, no influence more effective than a bright sky in obliterating meteor showers.) At the end of each period of observation I finally discussed the materials collected and deduced the radiants. In some instances a very definite little shower would be manifested from a single night's work, but I generally found it advisable to combine the paths recorded on several dates in order to obtain satisfactory positions.

The average length of path of all the meteors I have registered is 10·9 degrees.

The mean horary number (8·3) of meteors as given in my table is less than would be observed from a place where there is no interference from the light and smoke of a large town. My observations since 1883 were made in a neighbourhood rather subject to fogs and surrounded with gaslight. Before 1883 my position (at Ashley Down) was far more favourable, being much less affected by such influences. The following figures will show to what extent difference of locality may affect results of this nature :—

Year.	Duration of Obs.	Meteors seen.	Horary Number.
1877	230 hours	2250	11·4*
1887	278 „	2031	8·2

From places where there is much artificial illumination of the air small meteors elude detection. A little fog is also a serious hindrance, owing to its capacity of reflection. The above figures exhibit a balance of three meteors per hour in favour of the best station. Country places are obviously far better than towns for observations of this kind, and at sea the conditions are even better still.

As to the relative numbers which appear during the night, I find the maximum is attained between 2 and 3 A.M., when the rate is nearly double that observed in the early hours of the evening.

While watching for meteors I frequently noticed two of these bodies would appear at nearly the same time and from the same radiant. The probable explanation in such cases is that the two objects originally formed one mass which suffered disruption owing to the vicissitudes encountered in planetary space.

The intention of my observations being to determine radiant points, I have made few computations as to the heights of either

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* In deriving the horary numbers I have made allowances for time spent in registering the tracks, which must be subtracted from the aggregate duration of the observations.

fireballs or shooting stars. I gave, however, two lists of such results in the *Journal of the Liverpool Astronomical Society* for March 1888 and April 1889. Adding to these a few meteors, of which duplicate observations were made, in 1889, I find the following average values for thirty-eight instances, including fireballs and shooting stars :—

> Beginning height   71·1 miles.
> End height   ...   48·2 „

These results agree satisfactorily with the values assigned by other computers. From a comparison of a large number of other similar results I deduced the following general average :—

> Beginning height   76·4 miles (683 meteors).
> End height   ...   50·8   „   (756   „   ).

But, if fireballs and shooting stars are separated, I find the usual heights at disappearance are: fireballs, thirty miles ; shooting stars, fifty-four miles.

In the catalogue I have affixed the number of meteors observed from each radiant. With regard to the more feeble showers giving only three, four, or five meteors, I would remark that I regard them as the most interesting, and in a great number of cases as not the least certain of all. Great care has been taken to avoid erroneous positions. I have only included feeble radiants when the circumstances were special. Some of them include a stationary meteor, others a meteor observed at two stations. Others again are confirmed by another radiant of nearly similar date and place, and a proportion of them being near the horizon or in an isolated position could be determined from very few meteors. The small number of meteors to some of the radiants is not therefore any sign of their doubtful character. It is simply attributable either to feebleness in the systems themselves or to the unfavourable situation of their radiants. The average number of meteors to each position included in the catalogue is about nine.

The minor systems generally are of extreme tenuity, but the Earth encounters large numbers of them. Their radiants are only to be satisfactorily revealed by long-sustained watching and by undeviating exactness in recording their individual meteor flights. A finer climate than that of England would offer great advantages in a practical research of this kind and enable more productive materials to be obtained, but the result in the main would be similar, as indicating the extraordinary number of feeble and scarcely discernible systems of shooting stars. Could many observers combine to secure data of uniform accuracy and character, the investigation of these weak streams might be simplified : but there seems little prospect that such an arrangement can be effectively carried out.

A proportion of the showers represented in the catalogue apparently discharge not more than one meteor in five or seven hours, but I regard the radiant points as quite trustworthy, no means having been omitted to gather reliable positions, and to avoid all such as appeared due to the accidental intersection of the paths. Observing for thirty-three hours during the latter part of December 1886, I adopted a radiant at $77° + 32°$, which I thought sufficiently established, though it had supplied only five meteors during the whole period mentioned. The opinion was justified, as I found a few days later, for one of the most conspicuous of its meteors had been very carefully and fully observed from Sidmouth, and on computing its real path by comparison with the Bristol observation, the radiant above mentioned received exact corroboration.

I have frequently found that radiant points are very sharply defined, and believe that diffused positions are very often the outcome of inaccurate observation rather than a real feature of meteor swarms. The large area of radiation, manifested by the great storm of Andromedes in 1885, may be regarded as exceptional. When I began observing that shower on the early evening of November 27 I was immediately struck with the indefinite character of its radiant, and some trouble was experienced in assigning a good centre. Yet in regard to other showers, far less rich, a similar difficulty rarely presents itself. Undoubtedly a small proportion of the meteors diverging from many systems appears to be a little erratic and occasions some perplexity in the observer's mind as to the source of such discordances and how he may safely adjust his materials; but as a rule he will find the centres indicated with fair, if not excellent, precision. I have not infrequently marked about ten meteors from a minor stream, the paths of which have all intersected at a point. In other instances seven out of ten meteors would converge upon a sharp focus, while three others, unquestionably from the same system, proved erratic to the extent of $3°$ or $4°$. Errors in noting the directions induce some disagreements of this sort, but there is no doubt that a certain proportion of meteor flights really deviate several degrees from the radiant centres indicated by the bulk of the paths. The allotment of individual meteors to their respective radiants becomes therefore a critical feature in these reductions, and one which requires that the observed appearance of each meteor should be carefully considered before it is disposed of.

One of the most singular issues of my observations is that a comparatively large number of the showers detected apparently endure for a much longer period than can be admitted on the prevalent theory of their cometary origin. But in the catalogue I have confined the showers to single nights, and in another column specified a few other dates of activity. The method of attributing the radiants to the epochs of their maximum display has much to recommend it. It is concise and definite, and readily permits comparisons with the computed dates and radiant points

of comets. Moreover, it is consistent with theoretical views, according to which extreme brevity must form an essential feature of stationary radiant points. But it is in the highest degree probable that there is not a single meteoric display in the heavens but has a longer duration than twenty-four hours. The whole question as to the length of visibility of radiant points requires thorough investigation. A few of the positions become rapidly displaced amongst the stars, while many others remain fixed. The Perseids, it is certain, begin to fall as early as July 8 from a radiant at $3° + 49°$, and they do not cease until August 22, when the centre has passed to the point $78° + 58°$. On August 10, when the maximum is attained, the radiant is at $46° + 57°$, corresponding with that of Comet III. 1862. The Lyrids of April also exhibit a radiant which quickly changes its place during the few nights of its operation. On the other hand, the Orionids of October gave no evidence of a similar variation, for though the shower is maintained for three weeks (October 9–29) the radiant is all the time constant at about the point $92° + 15°$.

As to the fact of stationary radiation, which I fully recounted in a paper published in the *Monthly Notices* for December 1884, I have endeavoured to test it by about 5000 observations obtained during the five years which have elapsed since that time. These new materials appear to support the conclusions previously arrived at. In many cases the same radiant point (allowing for very trifling errors inseparable from the observations) is persistent during several months. This attitude is very unmistakable in its character and convincing in its proofs. In my paper above referred to, I mentioned the successively observed positions for a remarkably long-enduring shower between a and $β$ *Persei*, and of this particular stream, or succession of streams, I have secured several fresh determinations. It is to be regarded as one of the best instances of an apparently stationary radiant, and it may be interesting to append a summary of all my observations relating to its appearances at different times of the year :—

1877 July 20	$47 + 45$		1885	Sept. 15	$48 + 43$
1884 July 23–25	$48 + 43$		1877	Sept. 15–16	$47 + 45$
1886 Aug. 2–10	$48 + 43$		1886	Sept. 22–30	$48 + 44$
1888 Aug. 5–14	$48 + 44$		1887	Oct. 17–24	$47 + 44$
1877 Aug. 3–16	$46 + 45$		1879	Oct. 20	$45 + 46$
1884 Aug. 19–21	$46 + 44$		1879	Nov. 12–14	$48 + 43$
1879 Aug. 21–23	$46 + 47$		1877–86	Nov. 27–Dec. 8	$48 + 42$
1887 Aug. 30	$46 + 43$		1886–8	Dec. 28–Jan. 11	$47 + 44$
1887 Sept. 12–24	$47 + 43$		1876–87	Feb. 23–Mar. 12	$47 + 45$

The mean of the eighteen radiants is at $47°+44°$, and the whole interval over which they extend, from July 20 to March 12, $= 234$ days.

I have also strongly suspected this radiant at additional periods to those given, but the number of observed paths has not been sufficient to define it with absolute certainty. The positions in the table exhibit a very suggestive resemblance, and some of them it will be noticed are identical. In July and August these a–β Perseids are somewhat conspicuous, they move *very swiftly*, and leave bright streaks. In fact, they closely resemble the meteors of the great Perseid shower. In September the motions are still *very swift*, but the meteors are then devoid of streaks, except in the more brilliant instances. In October the speed has palpably slackened, my description of the flights being *moderately swift*, while at the middle of November I estimated them as *rather slow*. At the end of that month and early in December my records give *slow* and *very slow*, and this also applies to the meteors of this radiant, seen between December 28–January 11, and February 23–March 12.

This position between a and β *Persei* has been recognised at various epochs of the year by several other observers as the well-defined focus of a meteor shower. I have seen but little of it during the opening months, so it is satisfactory to find that it was observed by Heis (January 2–26 at $45°+44°$), Zezioli (January 11, $47°+40°$), and Greg and Herschel (March 1–15, $50°+47°$).

I may also make reference in this place to some observations of a prolonged shower which I traced during the very clear summer months of 1887 :—

June 10–28	$335 + 57$	10 meteors
July 14–23	$334 + 58$	6 „
Aug. 6–25	$334 + 58$	10 „
Sept. 17–22	$335 + 58$	12 „

There is also a display which indicates unusually definite radiation in September and all through the autumnal months following. The mean position of this is at $155°+40°$ near the stars μ, λ of *Ursa Major*. I allude to these isolated cases merely as furnishing good examples of a rather numerous class, of which I give a selected list at the end of the catalogue.

I refer to the existence of apparently stationary radiants merely as a fact of observation. The evidence supporting them is scarcely of a character to be disregarded. I have no theory whatever to substantiate by upholding a feature so anomalous, and confidently leave it for elucidation by future observers. There must, of course, be little parallelism of real direction, and considerable differences of orbit in the meteors of these long-enduring (or successively-recurring) displays, but in certain cases

at least the phenomena may be induced by the effects of planetary perturbations upon very wide streams. The subject both in its observational and theoretical bearings demands much more investigation.

It is certain that, inasmuch as the heavens are so thickly studded with radiant points, there must happen many close agreements in the apparent places of showers successively displayed, but which have no real physical association. This is proved by the circumstance that during the autumnal months there are several star showers directed from near η *Persei*, which is precisely the centre of the August Perseids on the date of its maximum. And there are some very definite radiants in July, August, and October from the identical point near γ *Andromedæ* which furnishes the Andromedes of Biela's Comet. But there can be no doubt that these accordances in the apparent astronomical radiant points are purely accidental. In the many other instances, however, afforded by the minor showers the facts are far more striking and must certainly arrest the attention of every observer who becomes deeply involved in accurate observations of shooting stars. In the last column of the catalogue I have notified a few comparisons with Lieut.-Colonel Tupman's " Catalogue of Observed Radiant Points " of shooting stars published in the *Monthly Notices,* vol. xxxiii., p. 300–5. Thus " T. 1," affixed to my first radiant, is intended to show that it is identical with Tupman's radiant No. 1.

Catalogue of Radiant Points of Shooting Stars.

No.	Year.	Date.	Radiant. α	δ	Other Nights of Observation.	No. of Meteors.	Appearance, &c.
1	1884	Jan. 1	222	+49	...	6	=913, 2, 5, 6, and 8. Quadrantids. T. 1.
2	1879	1	230	+51	...	14	Bright, white. Quadrantids.
3	1886	2	119	+16	Jan. 4	7	Rather swift, bright.
4	1886	2	167	+ 4	Dec. 31, Jun. 4	5	Very swift, streaks. T. 2.
5	1880	2	228	+54	...	19	Slowish, long paths. Quadrantids.
6	1886	2	228	+52	Dec. 31	8	Rather swift, bright. Quadrantids.
7	1877	4	57	−12	Jan. 8	7	Bright, very slow.
8	1877	4	231	+54	...	4	Not very swift, long. Quadrantids.
9	1886	5	72	+14	Jan. 2, 4, 8	5	Swift.
10	1886	5	140	+57	Jan. 2, 4	6	Swift, very short.
11	1886	8	329	+60	Dec. 29, Jan. 4	5	Slow, bright, trains.
12	1877	9	84	+74	Jan. 4, 6, 11	6	Swift, short.
13	1877	9	146	+ 4	Jan. 17	4	Slow, = 900. T. 3.
14	1877	9	209	+67	Jan. 11	7	Swift, white.
15	1877	9	221	+42	...	6	Swift, streaks.
16	1886	11	220	+13	Jan. 4	7	Very swift, streaks.
17	1877	11	248	+73	...	7	Very slow, yellow, trains.
18	1877	14	130	+44	Jan. 17	11	Rather swift, bright.

No.	Year.	Date.	Radiant α	Radiant δ	Other Nights of Observation.	No. of Meteors.	Appearance, &c.
19	1877	Jan. 14	179	+47	Jan. 17, 20, 21	9	Swift.
20	1877	14	209	+15	Jan. 20	5	Very swift, streaks.
21	1877	14	211	+4	Jan. 20	5	Very swift, streaks.
22	1877	14	250	+25	Jan. 17	10	Swift, short, streaks.
23	1877	14	260	+45	Jan. 17	6	Short, faint.
24	1877	17	160	+28	Jan. 19	6	Swift, white.
25	1877	17	295	+53	Jan. 14	20	Slowish, bright, trains.
26	1887	19	253	+56	Jan. 14, 17	5	Very slow, yellow.
27	1887	19	261	+63	Jan. 25	4	Rather slow.
28	1877	20	220	+52	Jan. 14	5	Rather slow.
29	1877	20	226	-2	Jan. 2, 1884	...	Swift, streaks.
30	1877	22	208	-8	Jan. 19, 20, 25	5	Very swift, streaks, = 37.
31	1887-9	25	131	+32	Jan. 29, Feb. 1	4	Rather swift.
32	1887	25	180	+24	...	5	Very swift.
33	1887-9	29	213	+52	Jan. 25	5	Very swift.
34	1889	Feb. 1	211	+69	Feb. 4	4	Slow, short.
35	1877	4	61	+28	Feb. 5	4	Rather swift.
36	1877	4	105	+29	Feb. 2	5	Very slow.
37	1877	15	210	-13	Feb. 21	5	Swift, streaks, = 30. T. 6.

Catalogue of Radiant Points of Shooting Stars.

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5	1880	2	228	+54	...	19	Slowish, long paths. Quadrantids.
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13	1877	9	146	+4	Jan. 17	4	Slow, =900. T. 3.
14	1877	9	209	+67	Jan. 11	7	Swift, white.
15	1877	9	221	+42	...	6	Swift, streaks.
16	1886	11	220	+13	Jan. 4	7	Very swift, streaks.
17	1877	11	248	+73	...	7	Very slow, yellow, trains.
18	1877	14	130	+44	Jan. 17	11	Rather swift, bright.

No.	Year.	Date.	Radiant α	Radiant δ	Other Nights of Observation.	No. of Meteors.	Appearance, &c.
19	1877	Jan. 14	179	+47	Jan. 17, 20, 21	9	Swift.
20	1877	14	209	+15	Jan. 20	5	Very swift, streaks.
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22	1877	14	250	+25	Jan. 17	10	Swift, short, streaks.
23	1877	14	260	+45	Jan. 17	6	Short, faint.
24	1877	17	160	+28	Jan. 19	6	Swift, white.
25	1877	17	295	+53	Jan. 14	20	Slowish, bright, trains.
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27	1887	19	261	+63	Jan. 25	4	Rather slow.
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31	1887–9	25	131	+32	Jan. 29, Feb. 1	4	Rather swift.
32	1887	25	180	+24	...	5	Very swift.
33	1887–9	29	213	+52	Jan. 25	5	Very swift.
34	1889	Feb. 1	211	+69	Feb. 4	4	Slow, short.
35	1877	4	61	+28	Feb. 5	4	Rather swift.
36	1877	4	105	+29	Feb. 2	5	Very slow.
37	1877	15	210	−13	Feb. 21	5	Swift, streaks, = 30. T. 6.

No.	Year.	Date.	Radiant α	δ	Other Nights of Observation	No. of Meteors	Appearance, &c.
38	1877	Feb. 15	236	+11	Feb. 20	10	Very swift. T. 10.
39	1877	15	261	+4	Feb. 20	4	Swift, streaks. T. 16.
40	1877	16	167	+5	Feb. 21	6	Slowish, streaks.
41	1877	20	181	+34	...	8	Very swift, bright. T. 4.
42	1877	20	234	+32	...	12	Swift.
43	1877	20	263	+36	Feb. 21	5	Swift.
44	1877	20	285	−15	...	...	Very swift, long.
45	1876–87	Mar. 1	47	+45	Feb. 23–27, Mar. 12	4	Very slow.
46	1886	4	176	+9	Mar. 3	4	Slowish, =48.
47	1877	8	189	+26	...	6	Slowish, faint.
48	1877	14	175	+10	Mar. 15	5	Slowish, bright, =46.
49	1877	14	218	+36	...	6	Slow.
50	1877	14	244	+50	...	6	Swift.
51	1877	14	250	+54	...	4	Swift.
52	1877	14	263	+48	...	6	Swift, streaks.
53	1877	14	277	+25	...	5	Not very swift.
54	1877	14	280	−14	...	...	Very swift, streaks.
55	1877	16	316	+46	Mar. 18	...	Slow, starlike.
56	1876	17	184	+54	Mar. 12	6	Swift.

No.	Year	Date	Radiant α	δ	Other Nights of Observation	No. of Meteors.	Appearance, &c.
57	1877	Mar. 17	252	+12	...	3	Swift.
58	1887	18	316	+76	Mar. 16, 24, 27, 28	5	Slow, bright.
59	1887	23	190	+20	Mar. 21, 24, 28	5	Swift.
60	1887	24	161	+58	Mar. 23, 25, 27	7	Swift.
61	1887	25	175	+20	Mar. 13, 27	5	Slow.
62	1887	27	229	+32	Mar. 25	6	Swift, faint.
63	1887	28	263	+62	...	5	Slowish.
64	1876	Apr. 11	230	+38	Apr. 13, 22	8	Slow.
65	1876	15	194	+30	...	10	Small.
66	1876	15	207	+48	Apr. 14, 16	7	Swift, short.
67	1877	16	210	−10	Apr. 7	5	Swift, streaks.
68	1876	16	241	+24	Apr. 17, 22	8	Rather swift.
69	1887	17	165	− 6	Apr. 18	5	Very slow.
70	1885	18	181	+35	...	4	Very slow, orange.
71	1885	18	226	± 0	Apr. 19, 20	4	Very slow, =79. T. 32.
72	1885	18	260	+33	...	6	Swift, bright, streaks. Lyrids.
73	1887	18	213	+53	Apr. 17, 19	7	Swift, short.
74	1887	18	231	+17	Apr. 19, 25	10	Swift, short, =98.
75	1887	18	266	+33	...	4	Swift, streaks. Lyrids.

No.	Year	Date	Radiant α	δ	Other Nights of Observation	No. of Meteors	Appearance, &c.
76	1887	Apr. 18	327°	+48	Apr. 19, 20	4	Slow, bright.
77	1885	19	213	+ 9	Apr. 18, 20	4	Very slow.
78	1887	19	218	+33	Apr. 18, 20, 25	5	Slow, bright.
79	1877	19	228	− 2	Apr. 16	5	Slow, =71. T. 32
80	1885	19	236	+62	Apr. 20	7	Slow.
81	1887	19	238	+46	Apr. 17, 18, 20, 25	5	Swift, short.
82	1887	19	254	+57	Apr. 18, 25	5	Slowish, short.
83	1877	19	255	+50	...	5	Swift.
84	1877	19	260	+ 2	...	4	Swift, white.
85	1877	19	267	+21	...	6	Swift, = 119.
86	1885	19	268	+33	...	10	Swift, bright. Lyrids.
87	1877	19	269	+37	Apr. 16	7	Rather swift. Lyrids.
88	1887	19	269	+31	...	5	Swift, streaks, Lyrids.
89	1887	19	230	+47	Apr. 17, 25	4	Slow.
90	1877	19	286	+ 5	...	12	
91	1877	19	289	− 15	Apr. 16, 25	5	Swift.
92	1877	19	298	+25	Apr. 16	6	Swift, streaks, = 121.
93	1877	19	303	+13	...	8	
94	1877	19	315	+38	...	10	

No.	Year.	Dat.	Radiant α	δ	Other Nights of Observation.	No. of Meteors.	Appearance, &c.
95	1887	Apr. 20	189	+20	Apr. 12, 25	7	Very slow.
96	1873	20	221	+20	Apr. 19, 21	9	Swift.
97	1885	20	226	+41	...	4	Not swift.
98	1885	20	230	+17	Apr. 19	5	Slowish, short, = 74.
99	1887	20	235	−15	Apr. 16, 19, 21	5	Slowish, long.
100	1874	20	242	+25	...	7	
101	1878	20	251	+31	Apr. 26	6	Very swift.
102	1884	20	269	+33	...	17	Slowish, short. Lyrids.
103	1887	20	271	+33	...	7	Very swift, streaks. Lyrids.
104	1878	20	272	+32	Apr. 21, 22	13	Swift. Lyrids.
105	1879	20	272	+33	...	8	Lyrids,
106	1873–4	19, 20	274	+37	Apr. 21	32	Swift, bright. Lyrids.
107	1885	20	274	+33	...	14	Swift, bright. Lyrids.
108	1879	20	286	+24	Apr. 19	4	Very swift, streaks.
109	1885	20	296	± 0	Apr. 18	4	Very, very swift, = 143.
110	1885	20	299	+24	Apr. 18, 19	5	Very swift, streaks, = 121.
111	1885	21	277	+67	Apr. 16, 20, 22	6	Swift, short.
112	1873	21	283	+59	...	5	Swift.
113	1878	21	293	+43	Apr. 22	4	Swift.

No.	Year	Date	Radiant. α	δ	Other Nights of Observation	No. of Meteors	Appearance, &c.
114	1876	Apr. 22	142	+40	Apr. 21	6	Swift.
115	1876	22	207	−7	...	5	Slow.
116	1876	22	223	+45	...	5	Swift.
117	1878	22	263	+62	Apr. 20, 21, 26	6	Swift.
118	1886	24	189	+58	Apr. 19, 26	6	Slow.
119	1887	25	272	+21	Apr. 18, 20, 27	12	Swift, short, =85.
120	1887	25	284	+21	Apr. 19	4	Swift, streaks, =108.
121	1887	25	302	+23	Apr. 19	4	Swift, short, =92 and 110.
122	1886	26	160	+59	Apr. 24, 30	5	Slow.
123	1886	26	255	+37	May 1, 3	5	Slowish.
124	1887	26	260	+62	Apr. 19	6	Slowish, =138 and 140.
125	1886	27	241	+61	Apr. 21, May 3, 4	8	Swift.
126	1886	30	257	+25	Apr. 25, May 3	4	Slow, trains.
127	1886	May 1	239	+46	May 4	8	Swift.
128	1885	3	195	+45	Apr. 24	10	Slow.
129	1886	3	265	+77	Apr. 26	5	Slow.
130	1886	3	345	+37	May 4	3	Slow.
131	1886	5	228	+33	May 1, 8	5	Rather slow.
132	1886	5	234	+10	Apr. 27, May 3, 4	8	Slowish.

No.	Year	Date	Radiant α	Radiant δ	Other Nights of Observation	No. of Meteors	Appearance, &c.
133	1886	May 5	254	−21	Apr. 30, May 6	5	Slowish.
134	1886	5	327	+34	Apr. 30, May 9	4	Very swift.
135	1886	6	337	−2	Apr. 30, May 1–5	11	Swift, streaks. T. 33.
136	1877	7	219	+17	...	4	Slowish.
137	1877	7	244	+7	May 2, 3, 11, 13	11	Slowish.
138	1886	8	264	+64	Apr. 30, May 5, 6,	6	Swift, =124 and 140.
139	1885	11	231	+27	May 7, 14–16, 18	8	Slow, short, small.
140	1885	11	262	+64	May 14	4	Slow, faint, =124 and 138.
141	1887	13	255	+56	May 16	4	Slow.
142	1885	14	314	+15	May 13, 16	5	Swift, streaks.
143	1877	15	294	± 0	...	6	Very swift, =109.
144	1877	15	304	+7	May 6	5	Swift, white.
145	1877	17	283	+55	...	4	Swift.
146	1877	17	354	+41	May 15	4	Not swift, streaks.
147	1886	29	264	+64	May 28, 30	4	Slowish, =155.
148	1886	29	333	+27	May 30, June 4, 9	6	Swift, streaks.
149	1877	30	20	+58	...	4	Bright, streaks.
150	1886	30	290	+60	...	5	Slow, yellow.
151	1886	30	304	+22	...	4	Swift, =121 and 167.

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No.	Year.	Date.	Radiant α	δ	Other Nights of Observation.	No. of Meteors.	Appearance, &c.
152	1886	June 4	313	+60	...	3	Very swift, streaks, =156.
153	1885	10	261	+5	June 3, 9, 13	7	Very slow.
154	1885	11	257	+32	June 10, 23	5	Slow.
155	1885	13	262	+64	June 9, 10	5	Slow, faint, =147.
156	1885	13	310	+61	...	4	Swift, streaks, =152.
157	1885	13	345	±0	June 11	3	Very swift, bright.
158	1887	15	285	+23	June 12, 17, 18, 21	11	Slowish.
159	1887	15	291	+52	June 10, 13, 17	8	Swift, small.
160	1887	17	252	+11	June 19, 20, 23	7	Slow.
161	1887	17	268	-24	June 10, 14, 19, 20	5	Very slow, bright.
162	1887	17	270	+47	June 13, 19, 21	5	Slow, bright.
163	1877	17	285	+32	June 15	5	Swift.
164	1887	17	295	+40	June 18, 23, 26	6	Not slow, =176.
165	1877	17	302	+64	June 14	5	Swift, short.
166	1837	18	274	+69	June 11, 12, 15, 19	9	Swift, short.
167	1887	18	302	+24	June 13, 20, 22	11	Rather swift, =151.
168	1887	20	280	+43	June 17, 21, 23	10	Swift, small.
169	1887	20	335	+57	June 10, 11, 28	10	Swift.
170	1887	21	290	+27	June 17, 25	6	Rather slow.

No.	Year	Date	Radiant. α	Radiant. δ	Other Nights of Observation.	No. of Meteors.	Appearance, &c.
171	1887	June 23	40	+56	June 14, 19, 25	4	Swift, streaks.
172	1887	25	238	+47	June 11, 21, 23, 26	7	Slow, small.
173	1887	26	213	+53	June 14, 28	4	Swift, bright.
174	1887	26	354	+39	June 14, 17, July 4, 6	9	Very swift, streaks.
175	1873	28	164	+57	June 25, July 8	5	Slow.
176	1886	28	294	+39	June 26, July 1, 4–6	9	Slow, very short, =164.
177	1886	July 1	219	+72	June 28	5	Swift, =187.
178	1886	1	339	+31	July 4, 5	4	Swift, streaks.
179	1886	4	303	+24	June 30, July 5, 7	6	Swift, =167.
180	1886	5	21	+23	July 6	4	Swift, streaks.
181	1886	5	315	+17	July 4, 6	4	Swift.
182	1886	5	316	+46	July 2, 6	5	Swift, short, =207.
183	1877	6	284	−13	July 12	5	Slow, =204. T. 36.
184	1886	6	313	+60	July 1, 4	4	Slow.
185	1877	7	4	+35	...	5	Very swift, streaks, =193.
186	1877	7	333	+26	July 6	11	Swift, white.
187	1875	7	344	+27	...	...	=178.
188	1888	8	3	+49	July 11	6	Very swift, streaks. Perseids.
189	1885	8	245	+52	July 11, 12	7	Very slow, yellow.

No.	Year.	Date.	Radiant. α	δ	Other Nights of Observation.	No. of Meteors.	Appearance, &c.
190	1888	July 8	310	+79	July 12	5	Swift, small, short.
191	1885	9	266	+63	July 12, 13	5	Slow.
192	1885	9	347	± 0	...	...	Swift, streaks.
193	1877	11	5	+35	...	6	Very swift, streaks, = 185.
194	1877	11	280	+57	...	5	Swift.
195	1877	11	290	+43	...	8	Swift.
196	1885	11	303	+39	July 9, 12	5	Slowish.
197	1888	11	319	+22	July 13	6	Rather swift.
198	1877	11	349	+53	July 12	10	Swift.
199	1877	12	6	+53	...	6	Swift, streaks, = 219.
200	1877	12	7	+37	...	5	Very swift, = 185 and 193.
201	1888	12	28	+30	July 11, 13	5	Swift, bright streaks.
202	1877	12	36	+47	...	6	Swift, streaks.
203	1877	12	271	+ 8	...	5	Very slow, orange.
204	1885	12	280	− 14	July 9, 11, 13	7	Very slow, trained, = 183.
205	1885	12	289	+31	July 9, 13	5	Very swift, short.
206	1877	12	295	+85	July 16, 17	6	Not swift.
207	1877	12	315	+48	July 11, 13	8	Swift, = 182, 216.
208	1885	12	329	+36	July 9, 13, 14	8	Rather swift, streaks.

No.	Year	Date	Radiant, α	δ	Other Nights of Observation	No. of Meteors.	Appearance, &c.
209	1877	July 12	338	+10	July 16, 17	10	Swift, bright, =225.
210	1885	13	6	+11	July 12	5	Very swift, streaks. T. 49.
211	1885	13	11	+48	July 11, 14	5	Very swift, streaks. Perseids.
212	1885	13	255	+37	July 12, 14, 16	6	Slowish, faint, =222.
213	1885	13	271	+21	July 12, 14	8	Slow, faint.
214	1885	13	290	+60	July 8, 9	5	Slowish.
215	1885	13	303	+24	July 9	4	Swift, faint, short.
216	1885	13	314	+47	July 14	5	Very swift, short, =207.
217	1885	14	285	+42	July 13, 17	5	Swift, =257.
218	1877	16	5	+35	...	5	Very swift, streaks.
219	1877	16	5	+52	...	11	Very swift, streaks, =199, 221.
220	1876	16	284	+57	July 15, 18	21	Very swift, faint.
221	1877	17	7	+53	...	5	Swift, streaks, =219.
222	1877	17	258	+37	...	6	Swift, =212.
223	1877	17	298	−8	...	5	Swift. T. 37.
224	1887	18	310	+9	July 14, 19, 22	9	Rather swift.
225	1887	18	333	+12	July 21, 22, 23	17	Swift, =209.
226	1887	19	19	+51	...	4	Swift, streaks. Perseids.
227	1873	19	267	+49	July 15, 20	5	Swift, =247, 256, 284.

No.	Year	Date	Radiant α	δ	Other Nights of Observation	No. of Meteors	Appearance, &c.
228	1887	July 19	314	+48	July 20, 21, 23	5	Swift, short, =216.
229	1876	19	330	+70	July 20	18	Swift, short.
230	1887	19	334	+58	July 14, 18, 22, 23	6	Swift.
231	1877	20	47	+45	...	5	Swift, streaks, =246.
232	1877	20	317	−11	...	13	Slow. T. 44.
233	1877	20	350	+37	July 12, 17	6	Swift, =239.
234	1878	21	50	+75	July 26, 27	5	Swift, short.
235	1876	21	298	+2	July 23	14	Not slow.
236	1887	22	16	+31	July 27, 29, Aug. 1	8	Swift, streaks.
237	1887	22	20	+65	July 27, Aug. 1	6	Swift, streaks, short, =244.
238	1887	22	25	+52	...	5	Swift, streaks. Perseids.
239	1887	22	351	+38	July 18, 31	6	Swift, =226, 249
240	1887	23	25	+52	...	4	Swift, streaks. Perseids.
241	1884	23	75	+31	...	4	Slowish, streaks, long.
242	1884	23	301	−14	July 25	8	Very slow, =268.
243	1887	23	335	+49	July 16, 18, 19, 27	16	Very swift, short, =310.
244	1876	24	18	+63	July 19, 20, 21, 23	28	Swift, streaks, =237.
245	1884	24	260	+68	...	5	Short, swift, =255.
246	1884	25	48	+43	July 21, 23, 24, 27	15	Swift, bright, streaks, =231.

No.	Year.	Date.	Radiant. α	δ	Other Nights of Observation.	No. of Meteors.	Appearance, &c.
247	1884	July 25	275	+47	...	5	Swift, short, faint, =227, 284.
248	1878	26	3	+35	...	5	Swift, streaks, =250.
249	1878	26	332	+37	July 25	11	Slowish.
250	1878	27	6	+34	...	5	Swift, streaks, =248.
251	1889	27	8	+52	July 26, 30	6	Swift, streaks.
252	1878	27	28	+28	July 27, 28, 31	7	Swift, streaks.
253	1878	27	28	+36	July 26, 28, 31	12	Swift, streaks, =279.
254	1887	27	29	+54	...	5	Swift, streaks. Perseids.
255	1887	27	260	+69	July 28, 29	7	Not swift, =245.
256	1889	27	271	+47	July 23, 31, Aug. 3	5	Slow, =247, 284.
257	1878	27	284	+44	July 28	4	Slow, brilliant, =217.
258	1878	27	354	+42	July 26	7	Slowish, faint, =276.
259	1878	28	7	+36	...	5	Swift, streaks, =250. T. 45.
260	1878	28	18	+58	...	8	Swift, streaks, =278.
261	1878	28	21	+22	...	5	Very swift, short.
262	1883	28	27	+55	...	10	Swift, streaks. Perseids.
263	1887	28	30	+55	...	10	Swift, streaks. Perseids.
264	1878	28	32	+53	July 27	10	Swift, streaks. Perseids.
265	1879	28	32	+53	...	9	Swift, streaks. Perseids.

No.	Year.	Date.	Radiant. α	δ	Other Nights of Observation.	No. of Meteors.	Appearance, &c.
266	1878	July 28	33	−20	...	...	Swift, bright, streaks.
267	1887	28	34	+18	July 27, 29, 31	8	Swift, streaks, =289.
268	1878	28	305	−15	...	5	Very slow, =242.
269	1887	28	314	+14	July 21, 27	7	Slowish.
270	1878	28	332	+27	July 27, 30, 31	8	Very swift, faint.
271	1878	28	333	+18	July 26, 27, 30, 31	8	Swift, faint.
272	1883	28	337	−11	...	18	Slow, trained, long. Aquarids.
273	1887	28	337	−12	July 25, 27, 29, 31	37	Slowish, long. Aquarids.
274	1879	28	338	−14	...	14	Slow, bright, long. Aquarids.
275	1878	28	341	−13	July 27, 30, 31	54	Slow, bright, long. Aquarids.
276	1877	28	350	+37	Aug. 4, 7, 10	5	Swift.
277	1878	29	7	+37	...	5	Swift, streaks, =259.
278	1887	29	21	+57	July 20, 28, Aug. 1	9	Swift, streaks, =260.
279	1879	29	30	+37	...	6	Swift, streaks, =253.
280	1887	29	31	+54½	...	10	Swift, streaks. Perseids.
281	1887	29	43	+39	July 31	5	Swift, streaks.
282	1880	29	257	+64	...	4	Slow, brilliant, =283.
283	1887	29	263	+61	Aug. 2	4	Slowish, =282.
284	1887	29	269	+49	July 20, 22, 23, 31	13	Swift, =256.

No.	Year	Date	Radiant α	δ	Other Nights of Observation	No. of Meteors.	Appearance, &c.
285	1887	July 29	322	-11	July 22, 27	5	Slowish, =232. T. 44.
286	1878	30	6	+35	...	6	Swift, streaks, =277.
287	1878	30	12	+52	July 25, 26, 30	13	Swift, streaks.
288	1878	30	20	+8	...	5	Swift, streaks.
289	1878	30	31	+18	July 31	4	Swift, streaks, =267.
290	1878	30	32	+53	July 31, Aug. 1	53	Swift, streaks. Perseids.
291	1878-89	30	134	+78	July 27, 28, 31	5	Slow.
292	1877	30	147	+62	Aug. 7	3	Slow, bright, yellow.
293	1885	31	5	+10	July 27, Aug. 1	6	Swift, streaks, =294.
294	1878	31	7	+11	Aug. 1	9	Very swift, streaks, =293.
295	1878	31	11	+47	July 30	13	Swift, streaks.
296	1878	31	12	+70	July 25, 29, Aug. 1	16	Swift, faint.
297	1887	31	35	+54	...	11	Swift, streaks. Perseids.
298	1878	31	43	+58	July 27, 28, 29	8	Swift, streaks.
299	1887	31	46	+26	July 22, 27, 29	8	Swift, streaks.
300	1878	31	49	+31	July 30, Aug. 2	5	Slowish.
301	1878	31	70	+50	July 30	5	Not swift, streaks.
302	1878	31	96	+72	July 30	5	Slow.
303	1878	31	331	+62	Aug. 1, 2	5	Slow, faint, =347.

No.	Year	Date	Radiant. α	δ	Other Nights of Observation.	No. of Meteors.	Appearance, &c.
304	1889	July 31	336	−13	July 27, 29, Aug. 3	6	Slow, long. Aquarids, =272-3-4-5.
305	1877	Aug. 1	23	+41	July 27, 31	7	Very swift, streaks.
306	1887	1	36	+56	...	4	Swift, streaks. Perseids.
307	1878	1	65	+60	July 30	7	Slow.
308	1877	1	291	+70	July 30, 31, Aug. 2	14	Swift, short.
309	1878	1	321	+31	July 31	10	Slow, bright.
310	1878	1	332	+50	July 26-31	14	Very swift, short, = 243.
311	1886	2	33	+55	...	12	Swift, streaks. Perseids.
312	1888	2	35	+54	...	14	Swift, streaks. Perseids.
313	1881	2	39	+55	...	14	Swift, streaks. Perseids.
314	1886	2	291	+51	July 27, 28, Aug. 6, 10, 11	14	Swift, = 330.
315	1878	2	333	+9	July 26-31	10	Very slow, = 348.
316	1888	2	336	−11	Aug. 5	3	Slow, bright. Aquarids.
317	1877	3	40	+56	...	20	Swift, streaks. Perseids.
318	1886	4	7	+11	Aug. 2, 10	5	Swift.
319	1877	4	9	+34	Aug. 3	5	Swift, streaks, = 336.
320	1886	4	20	+58	Aug. 2	6	Swift, streaks, = 337.
321	1886	4	26	+42	Aug. 10	6	Swift, streaks.
322	1877	4	30	+36	Aug. 10	13	Swift, = 279.

No.	Year	Date	Radiant α	δ	Other Nights of Observation	No. of Meteors	Appearance, &c.
323	1886	Aug. 4	32	+17	Aug. 2	5	Swift, =289, 323.
324	1886	4	37	+57	...	12	Swift, streaks.
325	1886	4	48	+43	Aug. 2, 10	10	Swift, streaks, =343.
326	1877	4	284	−12	Aug. 3, 5	4	Slow.
327	1877	4	340	−13	Aug. 3	4	Slow, bright. Aquarids, =304.
328	1886	4	350	+51	July 31, Aug. 2, 10, 11	11	Swift, =383.
329	1888	5	42	+57	...	11	Swift, streaks. Perseids.
330	1885	5	292	+52	Aug. 4	4	Slow, =314.
331	1887	6	31	+49	...	5	Swift, streaks, =376.
332	1887	6	42	+55	...	5	Swift, streaks. Perseids.
333	1886	6	334	+56	Aug. 4	4	Swift.
334	1878	7	3	+27	...	7	Not swift, bright.
335	1877	7	4	+20	Aug. 3	7	Swift.
336	1877	7	8	+38	...	5	Swift, =319, 356.
337	1877	7	18	+63	Aug. 12	15	Very swift, streaks, =320.
338	1877	7	40	+28	Aug. 3, 10, 12	8	Very swift, streaks.
339	1877	7	40	+56	...	20	Swift, streaks. Perseids.
340	1889	7	41	+58	...	10	Swift, streaks. Perseids.
341	1880	7	41	+55	...	14	Very swift, streaks. Perseids.

No.	Year.	Date.	Radiant. α	δ	Other Nights of Observation.	No. of Meteors.	Appearance, &c.
342	1887	Aug. 7	43	+56	...	5	Swift, streaks. Perseids.
343	1877	7	46	+45	Aug. 10	6	Swift, streaks, =325.
344	1889	7	69	+51	Aug. 6, 10	6	Swift, streaks.
345	1880	7	300	−10	Aug. 6, 9	5	Very slow, =268.
346	1877	7	315	+51	Aug. 4, 10, 12	13	Swift.
347	1889	7	329	+62	July 29, 31, Aug. 3	13	Swift.
348	1877	7	330	+10	...	12	Slow, =315.
349	1877	7	335	+45	Aug. 10, 12	18	Swift.
350	1877	7	343	+12	Aug. 4, 10, 12	8	Swift.
351	1880	8	41	+55	...	23	Very swift, streaks. Perseids.
352	1888	8	42	+57	...	20	Swift, streaks. Perseids.
353	1887	8	43	+56	...	5	Swift, streaks. Perseids.
354	1880	9	44	+55	...	71	Very swift, streaks. Perseids.
355	1879	9	46	+58	Aug. 11, 12	38	Very swift, streaks. Perseids.
356	1878	10	6	+37	...	6	Swift, streaks, =336, 369.
357	1877	10	8	+53	Aug. 12	9	Swift,
358	1887	10	42½	+57½	...	22	Swift, streaks. Perseids.
359	1878	10	{ 42½ +54, 44 +59 }		...	106	Swift, streaks. Perseids.

No.	Year	Date	Radiant α	δ	Other Nights of Observation	No. of Meteors	Appearance, &c.
360	1876	Aug. 10	43	+59	Aug. 5, 8, 11	43	Very swift, streaks. Perseids.
361	1877	10	43	+58	...	285	Very swift, streaks. Perseids.
362	1882	10	43	+57	...	8	Very swift, streaks. Perseids.
363	1874	10	44	+58¾	...	252	Very swift, streaks. Perseids.
364	1884	10	44	+59	...	16	Very swift, streaks. Perseids.
365	1886	10	44	+57	...	122	Swift, streaks. Perseids.
366	1880	10	45	+57	...	41	Very swift, streak. Perseids.
367	1877	10	70	+65	Aug. 12	10	Very swift.
368	1876	10	342	−12	Aug. 12	6	Slow, bright, long. Aquarids.
369	1877	11	8	+38	...	4	Swift, = 356, 375.
370	1887	11	45	+57½	...	16	Swift, streaks. Perseids.
371	1882	11	46	+57	...	45	Very swift, streaks. Perseids.
372	1886	11	47	+57	...	15	Swift, streaks. Perseids.
373	1880	11	48	+57	...	43	Very swift, streaks. Perseids.
374	1885	11	296	± 0	Aug. 5, 8, 13	4	Rather slow.
375	1877	12	10	+38	...	6	Swift, = 369.
376	1880	12	30	+46	Aug. 11, 13	5	Very swift, bright, streaks, = 331.
377	1877	12	31	+18	...	11	Swift, streaks, = 323.
378	1880	12	48	+57	...	19	Very swift, streaks. Perseids.

No.	Year.	Date.	Radiant. α	δ	Other Nights of Observation.	No. of Meteors.	Appearance, &c.
379	1877	Aug. 12	50	+55	...	14	Very swift, streaks. Perseids.
380	1877	12	60	+48	Aug. 10, 16	8	Swift, streaks, =403.
381	1879	12	215	+76	Aug. 9, 11	5	Slow, bright.
382	1877	12	330	+70	...	13	Swift, short, =437.
383	1877	12	349	+53	Aug. 3, 7, 13	4	Swift, =328, 410.
384	1888	13	8	+33	Aug. 8, 14	5	Swift, streaks, =375.
385	1888	13	23	+36	Aug. 8	5	Swift, streaks.
386	1880	13	49½	+57½	...	7	Very swift, streaks, Perseids.
387	1888	13	52	+57	...	13	Swift, streaks. Perseids.
388	1885	13	51	+58	...	6	Very swift, streaks. Perseids.
389	1888	13	104	+79	Aug. 5, 8	5	Very swift, very short.
390	1888	13	312	+15	Aug. 2	5	Very slow, brilliant.
391	1885	13	329	+8	Aug. 15	7	Slow, brilliant.
392	1888	14	0	+53	Aug. 8, 13	6	Swift.
393	1887	14	23	+30	Aug. 21, 24	7	Swift.
394	1888	14	48	+44	Aug. 8, 9, 13	5	Swift, bright, streaks, =413.
395	1887	14	53	+57	...	8	Swift, streaks. Perseids.
396	1888	14	302	+24	Aug. 8, 13	4	Not swift, bright, = 397.
397	1887	14	302	+23	Aug. 18, 21, 22	6	Rather slow, =396.

	Year.	Date.	Radiant. α	δ	Other Nights of Observation.	No. of Meteors.	Appearance, &c.
398	1887	Aug. 14	320	+11	Aug. 22, 24	5	Slow.
399	1887	14	335	−10	Aug. 11	5	Very slow. Aquarids.
400	1877	16	10	+37	...	4	Swift, =384.
401	1877	16	22	+46	Aug. 12	7	Swift.
402	1877	16	60	+59	...	5	Swift, streaks. Perseids.
403	1877	16	61	+48	...	4	Swift, streaks, = 380, 432.
404	1877	16	292	+48	Aug. 10, 12	7	Swift, =407.
405	1885	16	318	− 9	Aug. 17	5	Slow.
406	1885	16	323	+27	Aug. 15, 17	5	Slow.
407	1885	17	292	+52	Aug. 15	5	Slow, = 404.
408	1885	17	317	+22	Aug. 15, 20	5	Slow, faint.
409	1885	17	345	± 0	Aug. 16, 18, 20	7	Swift, = 440.
410	1885	17	345	+53	Aug. 16, 18, 20	10	Swift, = 383.
411	1884	19	25	+42	Aug. 21	5	Swift, streaks, = 441.
412	1885	20	5	+12	Aug. 17	7	Slewish.
413	1884	20	46	+44	Aug. 19, 21	4	Swift, streaks, = 394.
414	1887	20	242	+49	Aug. 22, 25	7	Very slow.
415	1887	20	297	+55	Aug. 14, 21	6	Slow.
416	1884	20	313	+10	Aug. 19	8	Very slow, yellow, trains.

No.	Year,	Date.	Radiant. α	δ	Other Nights of Observation.	No. of Meteors.	Appearance, &c.
417	1884	Aug. 20	331	+37	Aug. 23	8	Short, swift, faint.
418	1885	20	351	+38	Aug. 16	5	Swift.
419	1884	21	5	+35	Aug. 20, 22	5	Swift.
420	1887	21	5	+54	Aug. 14	8	Swift, streaks.
421	1887	21	39	+28	Aug. 18	6	Swift, streaks. T. 48.
422	1879	21	40	+59	Aug. 20	7	Swift, streaks.
423	1887	21	54	+71	Aug. 14, 20	10	Very swift, streaks.
424	1887	21	73	+41	Aug. 7, 20, 22	10	Very swift, streaks. T. 66.
425	1879	21	253	+64	Aug. 22	7	Slow, trained, =449.
426	1884	21	263	+69	Aug. 23	7	Rather slow.
427	1887	21	296	+86	Aug. 22	4	Slowish. T. 52.
428	1879	21	332	+59	Aug. 22	5	Slow, =472.
429	1879	21	339	−10	Aug. 22, 23	16	Slow, bright. Aquarids.
430	1887	21	347	+15	Aug. 20, 23, 24	7	Slowish, =453.
431	1879	22	5	+17	Aug. 21, 23	8	Slow (5° too far N.)? =456.
432	1879	22	61	+50	Aug. 21, 23	11	Swift, streaks, =403, 459.
433	1879	22	70	+66	Aug. 21, 23	9	Swift, streaks, =477.
434	1879	22	266	+47	...	7	Slow.
435	1879	21, 22, 23	291	+60	Aug. 25	56	Slow, bright, trains, =461.

No.	Year	Date	Radiant α	Radiant δ	Other Nights of Observation	No. of Meteors	Appearance, &c.
435	1879	Aug. 22	315	+47		6	Slow, white.
437	1879	22	330	+69	Aug. 21	7	Slow, bright, trains, = 382, 439.
438	1884	22	331	+7	Aug. 19, 20, 23	10	Slow, bright, trains.
439	1886	22	331	+71	Aug. 24	8	Swift, = 437, 452.
440	1879	22	350	±0	Aug. 21, 23	10	Slow, = 409, 463.
441	1879	23	24	+42	Aug. 21, 22, 25	9	Very swift, streaks, = 411.
442	1887	23	26	+72	Aug. 21, 24, 30	5	Swift, short, = 466.
443	1887	23	32	+50	Aug. 14, 20, 21	5	Swift.
444	1887	23	43	+39	Aug. 24, 25	9	Swift, streaks.
445	1879	23	46	+47	Aug. 21, 22	9	Very swift, streaks, = 480.
446	1884	23	60	+28	Aug. 21	4	Swift, streaks.
447	1879	23	62	+35	Aug. 21, 22, 25	10	Very swift, bright, streaks, = 468.
448	1884	23	70	+50	Aug. 21, 22, 25, 26	11	Swift, streaks.
449	1887	23	264	+62	Aug. 14, 20, 22	7	Slow, bright, trains, = 425.
450	1879	23	319	+30	Aug. 21, 22	12	Slow.
451	1887	23	327	+48	Aug. 21	8	Slow. T. 54.
M 452	1884	23	330	+68	Aug. 19, 20, 21, 25	10	Slow, = 439, 475.
M 453	1879	23	343	+14	...	6	Swift, bright, = 430.
454	1879	23	350	+47	...	8	Rather slow, = 464.

No.	Year.	Date.	Radiant. α	δ	Other Nights of Observation.	No. of Meteors.	Appearance &c.
455	1884	Aug. 23	352	+13	Aug. 21, 25	5	Short, swift, faint.
456	1887	24	5	+12	Aug. 21, 22	4	Swift, = 412, 431, 465.
457	1887	24	8	+45	Aug. 21, 22	5	Swift, short, streaks.
458	1884–δ	24	16	+31	Aug. 19, 20, 21	5	Swift, streaks.
459	1887	24	60	+50	Aug. 21	5	Very swift, streaks, = 432.
460	1887	24	135	+78	Aug. 20, 21, 22	7	Swift.
461	1887	24	289	+60	Aug. 21	5	Very slow, = 435. T. 58.
462	1886	24	315	+42	Aug. 27, 28, 29	7	Swift.
463	1886	24	346	+1	Aug. 29	5	Swift, = 440.
464	1887	24	349	+49	Aug. 21, 22, 25	11	Rather slow, = 454.
465	1884	25	5	+10	Aug. 23	7	Slow, bright, short, = 456.
466	1884	25	26	+70	...	5	Rather swift, = 442.
467	1884	25	30	+36½	...	7	Swift, streaks.
468	1884	25	62	+37	...	4	Swift, streaks, = 447.
469	1884	25	74	+15	...	...	Swift, streaks.
470	1887	25	301	+41	Aug. 22, 24	5	Slow.
471	1887	25	311	+65	Aug. 23	4	Very swift, = 481.
472	1887	25	334	+58	Aug. 6, 20, 21, 24	10	Rather swift, = 428.
473	1881	27	75	+33	...	5	Swift, streaks.

No.	Year.	Date.	Radiant. α	δ	Other Nights of Observation.	No. of Meteors.	Appearance, &c.
474	1881	Aug. 27	330	+36	Aug. 25, 26	6	Slowish.
475	1881	27	330	+69	...	4	Slow, =452, 518.
476	1884-6	28	1	+63	Aug. 20, 25, 27	7	Slow, short.
477	1886	29	70	+65	Aug. 27, 28	5	Swift, streaks, =433.
478	1886	29	106	+52	...	6	Not swift.
479	1886	29	292	+70	Aug. 28	11	Swift, streaks.
480	1887	30	46	+43	Aug. 14, 24	4	Swift, streaks, =445.
481	1888	30	313	+65	Aug. 29, Sept. 7	6	Rather swift, short, =471.
482	1877	31	160	+78	Sept. 4, 5	6	Swift.
483	1885	Sept. 3	62	+37	...	7	Swift, streaks, =495.
484	1885	3	243	+48	Sept. 4	5	Very slow, yellow.
485	1885	3	253	+54	Sept. 4, 5	7	Very slow, yellow.
486	1885	3	311	+50	Sept. 4	4	Swift.
487	1885	3	354	+38	Sept. 1, 4, 5, 7	19	Very swift.
488	1877	4	28	+45	Sept. 15, 16	4	Rather swift.
489	1877	4	40	+72	Sept. 15, 16	6	Swift.
490	1877	4	286	+27	Sept. 1	4	Slow, faint.
491	1885	4	346	±0	Sept. 1, 3, 8, 9	12	Slow, bright.
492	1885	5	4	−2	Sept. 3	5	Rather swift, =522.

No.	Year	Date	Radiant α	Radiant δ	Other Nights of Observation	No. of Meteors	Appearance, &c.
493	1877	Sept. 5	16	+54	Sept. 4	8	Swift, = 521.
494	1877	5	53	+64	Sept. 7	6	Swift, streaks.
495	1877-85	5	60	+35	Sept. 4	5	Swift, streaks, = 483, 500.
496	1885-8	5	61	+49	Sept. 6, 8, 9	7	Swift, = 504.
497	1877	5	70	+85	Sept. 4	7	Swift.
498	1877	5	85	+53	Sept. 4	8	Swift.
499	1888	6	48	+63	Sept. 7	5	Swift, streaks.
500	1880	6	61	+36	Sept. 2	4	Swift, streaks, = 495, 503.
501	1877	6	220	+78	Sept. 4, 7	10	Swift.
502	1888	6	354	+67	Aug. 29, Sept. 9, 10	6	Rather swift.
503	1877	7	60	+38	...	5	Swift, streaks, = 500, 505.
504	1877	7	61	+48	Sept. 4, 5	5	Swift, = 496.
505	1886	7	62	+36	Aug. 28	6	Swift, streaks, = 503, 511.
506	1877	7	73	+14	...	7	Swift, streaks, = 516.
507	1877	7	100	+58	Sept. 5	10	Swift.
508	1877	7	260	+63	Sept. 5, 15	8	Swift.
509	1877	7	267	+20	Sept. 4	4	Slow.
510	1888	7	314	+26	Aug. 29	5	Slow.
511	1885	8	62	+37	Sept. 9, 10	4	Swift, streaks, = 505.

No.	Year	Date	Radiant α	δ	Other Nights of Observation	No. of Meteors	Appearance, &c.
512	1885	Sept. 8	332 } 335 }	+32 } +28 }	Sept. 9, 10, 11	10	Slow, faint.
513	1887	8	358	+60	Sept. 7, 12, 15	10	Slowish.
514	1888	9	33	+54	Sept. 6, 7	5	Swift, streaks.
515	1888	9	46	+23	Sept. 7	4	Very swift, streaks.
516	1885	9	72	+14	Sept. 19	5	Swift, streaks, = 506.
517	1885	9	87	+20	Sept. 19	4	Very swift, streaks, = 538.
518	1885	9	335	+71	Sept. 4, 5	7	Slow, bright, = 475.
519	1877	12	10	± 0	Sept. 10	5	Swift.
520	1885	12	73	+43	Sept. 15	4	Swift, short, = 549.
521	1887	13	20	+56	Sept. 22	5	Slowish, = 493.
522	1879	14	1	– 5	Sept. 15	7	Very slow, = 492.
523	1879	14	50	+54	...	7	Swift.
524	1879	14	54	+10	...	6	Swift, streaks.
525	1879	14	60	+29	Sept. 8	5	Swift, streaks.
526	1879	14	70	+ 4	Sept. 25	5	Swift, streaks.
527	1879	14	76	+33	Sept. 20, 21	10	Swift.
528	1879	14	82	+75	Sept. 18, 25	8	Not very swift, streaks.
529	1885	15	5	+11½	Sept. 12	8	Slow, = 561.

No.	Year	Date	Radiant α	δ	Other Nights of Observation	No. of Meteors	Appearance, &c.
530	1885	Sept. 15	13	+ 6	Sept. 13, 17	7	Swift.
531	1885	15	25	+71	Sept. 12, 17	4	Swift, = 557.
532	1879	15	30	+36	Sept. 14	8	Slowish, = 567.
533	1885	15	48	+43½	Sept. 9	6	Very swift, = 545.
534	1877	15	49	+14	Sept. 7, 16	6	Swift, streaks.
535	1877	15	61	+48	Sept. 15	5	Swift, = 569.
536	1877	15	72	+14	Sept. 16	7	Swift, streaks.
537	1885	15	77	+57	Sept. 17	7	Very swift, streaks, = 570.
538	1877	15	88	+17	Sept. 16	8	Swift, streaks, = 517.
539	1877	15	101	+11	Sept. 16	5	Swift, streaks, = 590.
540	1877	15	113	+24	Sept. 16	4	Not swift, long, = 592.
541	1877	15	130	+46	...	5	Swift, streaks.
542	1877	15	156	+41	Sept. 5, 16	5	Swift, streaks.
543	1879	15	355	+18	...	8	Slow, bright, = 582.
544	1877	16	20	+ 8	...	8	Very slow, = 562.
545	1877	16	47	+45	Sept. 15	7	Swift, = 533.
546	1877	16	50	+31	Sept. 18, 19	7	Slow.
547	1877	16	59	+ 9	Sept. 15	5	Swift, streaks.
548	1877	16	61	+36	Sept. 15	16	Swift, streaks, = 553.

No.	Year.	Date.	Radiant. α	Radiant. δ	Other Nights of Observation.	No. of Meteors.	Appearance, &c.
549	1879	Sept. 16	72	+41	Sept. 15	6	Swift, streaks, = 520, 571.
550	1877	16	87	+34	Sept. 13, 15, 18	13	Swift, = 600.
551	1887	17	13	+38	Sept. 10, 15	5	Swift.
552	1887	17	55	+71	Sept. 15, 18, 24	5	Swift, streaks.
553	1885	17	62	+37	...	4	Swift, streaks, = 548.
554	1887	17	64	+22	Sept. 18, 22, 24	8	Swift, streaks, = 577.
555	1887	17	69	+70	Sept. 17, 19	6	Swift, streaks.
556	1885	17	345	± 0	...	4	Slow, bright, long.
557	1887	18	28	+72	Sept. 12, 22	7	Slowish, short, = 531.
558	1887	18	41	+38	Sept. 17, 19	7	Swift, streaks, = 565.
559	1887	18	87	+56	Sept. 17, 19	6	Swift, streaks, ? = 537.
560	1887	18	110	+82	Sept. 12, 24	5	Slowish.
561	1887	19	5	+10	Sept. 13, 17, 18, 22	15	Slow, short, = 529, 574.
562	1885	19	20	+14	...	4	Slow, = 544.
563	1887	19	75	+15	Sept. 13, 18, 22	6	Swift, streaks, = 599.
564	1876	20	14	+50	Sept. 18, 21	8	Rather slow.
565	1876	20	40	+40	...	5	Very swift, streaks, = 558.
566	1879	20	192	+79	Sept. 18, 21, 25	9	Very, very slow.
567	1879	21	30	+36	Sept. 25	8	Slowish, long, = 532.

No.	Year	Date	Radiant α	δ	Other Nights of Observation	No. of Meteors.	Appearance, &c.
568	1879	Sept. 21	31	+19	Sept. 25	10	Slow, small, trains, = 586.
569	1879	21	61	+48	Sept. 14	8	Swift, = 535, 576.
570	1879	21	76	+56	Sept. 25	7	Not very swift, streaks, = 537.
571	1879	21	76	+44	...	8	Swift, streaks, = 549, 578.
572	1879	21	80	+25	Sept. 20, 25	4	Swift, streaks.
573	1879	21	87	+43	...	8	Very swift, streaks, = 588.
574	1884	22	7	+10	...	5	Slow, short, = 561.
575	1887	22	43	+7	Sept. 18, 26	5	Swift, streaks.
576	1884	22	59	+49	Sept. 21	5	Very swift, = 569.
577	1886	22	63	+23	Sept. 21	7	Swift, streaks, = 554.
578	1884	22	73	+45	...	8	Swift, streaks, = 571, 606.
579	1886	22	85	+72	Sept. 18, 20	7	Swift.
580	1886	22	292	+71	Sept. 30	10	Slowish, streaks.
581	1887	22	335	+58	Sept. 17, 18, 19, 20	5	Slow.
582	1886	22	353	+18	Sept. 27	5	Slow, = 543.
583	1886	22	357	+25	Sept. 18	5	Rather swift.
584	1887	24	7	+44	Sept. 13, 15, 22	7	Slowish.
585	1884	24	16	+33	Sept. 22, 27	4	Slow, bright.
586	1887	24	34	+19	Sept. 20	5	Rather swift, = 568, 604.

No.	Year	Date	Radiant α	Radiant δ	Other Nights of Observation	No. of Meteors.	Appearance, &c.
587	1879	Sept. 25	31	+52	Sept. 21	5	Slow, faint, =633.
588	1878	25	87	+42	Sept. 26	5	Very swift, streaks, =573.
589	1879	25	99	+43	Sept. 21	15	Very swift, streaks, =608.
590	1879	25	103	+11	Sept. 21	5	Very swift, long paths, = 539.
591	1878	25	105	+73	Sept. 26	5	Not swift, = 609.
592	1879	25	108	+24	Sept. 21	5	Very swift, streaks, long, = 540.
593	1879	25	119	+15	...	3	Swift, streaks.
594	1878	25	127	+58	...	4	Swift, streaks.
595	1887	26	108	+43	Sept. 24	5	Very swift, streaks.
596	1884	26	271	+22	Sept. 27	...	Very slow, bright, trains.
597	1886	27	14	+12	Sept. 22, 30	8	Slowish, bright.
598	1886	27	48	+44	Sept. 22	6	Swift, = 545, 621.
599	1886	27	75	+15	Oct. 2	10	Swift, streaks, bright, = 563, 637.
600	1886	27	87	+35	...	5	Swift, streaks, = 550.
601	1886	27	115	+52	Sept. 22, Oct. 2	8	Swift, streaks.
602	1886	30	25	+71	Sept. 30, Oct. 2	5	Swift, = 623.
603	1886	30	347	±0	Sept. 20, 26, Oct. 4	5	Slow, bright.
604	1886	Oct. 2	32	+19	Sept. 27, 30	5	Slowish, = 586, 628.
605	1877	2	50	+85	Oct. 1, 3	9	Swift.

No.	Year.	Date.	Radiant. α	δ	Other Nights of Observation.	No. of Meteors.	Appearance, &c.
606	1886	Oct. 2	73	+41	Sept. 20, 27, 30	7	Swift, streaks, = 578.
607	1886	2	98	+29	Sept. 27	5	Swift, streaks.
608	1886	2	98	+43	Sept. 27	6	Swift, streaks, = 589.
609	1877	2	100	+73	Oct. 3	9	Very swift, = 591.
610	1886	2	115	+80	...	6	Swift, streaks.
611	1877	2	225	+52	...	7	Slow, trained, very bright.
612	1886	2	339	+64	Sept. 27, Oct. 2	6	Swift.
613	1877	3	167	+75	...	5	Swift, streaks.
614	1877	4	108	+38	Oct. 5, 6, 8	16	Very swift, streaks, = 648.
615	1877	4	133	+79	Oct. 3, 5, 7	22	Swift, streaks.
616	1877	4	186	+71	Oct. 3, 5	6	Slowish.
617	1877	4	253	+64	Oct. 2, 3, 5	4	Swift, = 630.
618	1877	4	290	+70	Oct. 2, 3, 5	7	Rather slow.
619	1877	4	310	+77	Oct. 3, 5, 8	17	Slowish.
620	1885	5	7	+35	Oct. 1, 7	4	Very slow, = 631.
621	1877	5	47	+45	Oct. 7, 8	5	Not very swift, = 598.
622	1877	5	56	+52	Oct. 8	4	Rather slow.
623	1879–85	6	25	+71	Oct. 4, 7, 8	7	Slowish, = 602, 644.
624	1885	6	54	+71	Oct. 5	4	Slow.

No	Year.	Date.	Radiant. α	δ	Other Nights of Observation.	No. of Meteors.	Appearance, &c.
625	1879	Oct. 6	315	+58	Oct. 4, 11	11	Rather swift, = 694.
626	1885	7	23	+17	Oct. 5	5	Rather slow.
627	1885	7	31	+8	...	5	Slow, = 653.
628	1885	7	31	+18	Oct. 8	10	Slow, bright, = 604.
629	1877	7	47	+16	Oct. 8	5	Swift.
630	1885	7	262	+64	Oct. 5, 12	5	Very slow, = 617.
631	1877	8	8	+35	Oct. 14	7	Swift, = 620.
632	1877	8	30	+36	Oct. 5, 7	10	Swift, short, = 670.
633	1877	8	32	+50	...	8	Slow, = 587.
634	1885	8	42	+55	Oct. 6, 12, 16	13	Slow, faint, = 656.
635	1877	8	47	+28	...	8	Short, swift, 655.
636	1877	8	61	+47	Oct. 16, 17	8	Very swift, bright.
637	1877	8	74	+14	Oct. 16	4	Swift, faint, = 599.
638	1877	8	77	+31	Oct. 5, 16	9	Swift, streaks, = 658.
639	1877	8	80	+21	...	9	Very swift.
640	1877	8	84	+55	Oct. 5	18	Swift.
641	1877	8	103	+12	Oct. 15, 19	22	Very swift, streaks.
642	1877	8	133	+68	Oct. 5, 15	10	Swift, = 664.
643	1887	11	13	+6	...	5	Slow, bright.

No.	Year	Date	Radiant α	δ	Other Nights of Observation.	No. of Meteors.	Appearance, &c.
644	1887	Oct. 11	29	+72	Oct. 12, 14, 15, 21	13	Small, short, = 623, 650.
645	1887	12	42	+38½	Oct. 14, 15	6	Swift, short.
646	1887	12	87	+42	Oct. 11, 14, 15	9	Swift, streaks. T. 92.
647	1887	12	91	+17	Oct. 11, 13, 14	5	Swift, streaks. Orionids.
648	1885	12	103	+33	Oct. 6, 8	8	Swift, streaks, = 614.
649	1876	13	14	+50	Oct. 14, 15	7	Slowish, faint.
650	1876	13	32	+70	Oct. 14, 15	5	Slow, faint, = 644.
651	1887	13	192	+83	Oct. 11, 14	10	Slow, bright.
652	1877	14	21	+55	...	5	Slowish.
653	1879	14	31	+9	Oct. 15	31	Slow, trained, faint, = 627.
654	1887	14	40	+20	Oct. 12, 13, 15-24	45	Rather swift.
655	1887	14	40	+29	Oct. 11, 13, 15	11	Swift, short, = 635, 671.
656	1877	14	43	+58	Oct. 8	6	Swift, faint, = 634, 657.
657	1879	14	48	+60	...	6	Very swift, streaks, = 656.
658	1876	14	76	+33	Oct. 15	7	Swift, = 638. T. 83.
659	1876	14	90	+58	Oct. 17, 25	6	Swift, streaks.
660	1879	14	95	+46	Oct. 15, 20	11	Very swift, streaks.
661	1887	14	105	+22	Oct. 15, 20, 21	12	Very swift, streaks, = 677.
662	1879	14	114	+62	Oct. 15	7	Very swift, streaks.

No.	Year	Date	Radiant α	Radiant δ	Other Nights of Observation.	No. of Meteors.	Appearance, &c.
663	1887	Oct. 14	117	+47	Oct. 15, 17, 20	8	Swift, streaks.
664	1887	14	135	+68	Oct. 15, 17, 20, 23	11	Swift, =642.
665	1879	14	152	+38	Oct. 15	7	Swift, streaks, bright, = 693.
666	1879	15	7	+51	Oct. 19, 20	11	Slow, faint.
667	1876	15	21	+14	Oct. 13, 14, 19	8	Very slow, bright, =626.
668	1879	15	24	+36	...	4	Slow.
669	1887	15	25	+44	Oct. 14	10	Small, slow, short.
670	1876	15	31	+37	Oct. 13, 14, 19	5	Swift, =632.
671	1876	15	46	+26	Oct. 14, 17	19	Swift, =655.
672	1879	15	70	+65	Oct. 14, 20	6	Swift, ? = 673.
673	1887	15	71	+61	Oct. 13, 21	5	Swift, ? = 672.
674	1879	15	78	+57	Oct. 14	12	Swift, streaks.
675	1887	15	91	+16	...	17	Swift, streaks. Orionids.
676	1879	15	105	+50	Oct. 14, 16, 20	5	Very swift, streaks, = 704.
677	1879	15	106	+23	Oct. 20	14	Very swift, streaks, = 661.
678	1887	15	109	+77	Oct. 14, 20, 21	7	Swift, small, short.
679	1879	15	124	+54	Oct. 20	4	Swift, streaks, = 688.
680	1877	15	133	+21	Oct. 16, 17, 18	18	Very, very swift. T. 88.
681	1879	15	133	+48	Oct. 14, 20	6	Swift, streaks, = 689.

No.	Year	Date	Radiant α	δ	Other Nights of Observation	No. of Meteors	Appearance, &c.
682	1877	Oct. 15	178	+34	Oct. 16	4	Swift, short.
683	1877	15	213	+79	...	8	Not very swift, =725.
684	1887	15	354	+69	Oct. 11, 14	6	Slow.
685	1887	16	85	+10	Oct. 17	7	Swift.
686	1887	16	119	+31	Oct. 6, 15	13	Swift, streaks.
687	1877	16	120	+15	Oct. 17	9	Very swift.
688	1877	16	127	+58	Oct. 17, 18.	10	Swift, streaks, =679.
689	1877	16	130	+47	Oct. 15, 17, 18	11	Swift, streaks, =681.
690	1885	16	133	+38	Oct. 8, 12	5	Swift.
691	1877	16	140	+28	Oct. 15, 17, 18	9	Swift, streaks.
692	1885	16	143	+49	Oct. 6	6	Swift, streaks.
693	1877	16	153	+42	Oct. 15, 17	4	Swift, streaks, =665.
694	1879	16	316	+60	Oct. 20	6	Swift, short, =625.
695	1876	17	38	+12	Oct. 14, 15, 25	5	Very slow.
696	1877	17	63	+22	...	7	Slowish, =724.
697	1876	17	88	+17	Oct. 19	8	Swift, streaks. Orionids.
698	1887	17	90	+15	...	3	Swift, streaks. Orionids.
699	1884	17	92	+14	...	4	Swift, streaks. Orionids.
700	1877	17	100	+1	Oct. 16, 18	5	Swift. T. 87.

No.	Year	Date.	Radiant. α	Radiant. δ	Other Nights of Observation.	No. of Meteors.	Appearance, &c.
701	1887	Oct. 17	312	+77	Oct. 12, 14, 15	8	Swift.
702	1874	18	34	+18	Oct. 17	5	Swift, bright.
703	1877	18	92	+15	Oct. 17	57	Swift, streaks. Orionids.
704	1877	18	105	+50	Oct. 15, 16, 17	15	Very swift, =676, 719.
705	1877	18	121	± 0	Oct. 16, 17	6	Swift.
706	1877	19	84	−11	Oct. 15, 16, 17	7	Swift, streaks.
707	1887	19	90½	+15½	...	10	Swift, streaks. Orionids.
708	1879	20	45	+ 6	...	8	Slow, =721. T. 81.
709	1879	20	45	+46	Oct. 15	6	Swift, =710.
710	1887	20	47	+44	Oct. 17, 19, 21, 23	9	Swift, =709.
711	1879	20	71	+51	...	7	Swift.
712	1887	20	90	+14½	...	22	Swift, streaks. Orionids.
713	1879	20	93	+17	Oct. 15	39	Swift, streaks. Orionids.
714	1879	20	106	+12	Oct. 14, 15	7	Very swift, streaks, long.
715	1876	21	11	+ 8	Oct. 19	9	Very slow.
716	1887	21	54	+71	Oct. 14, 15, 20, 23	12	Swift.
717	1887	21	75	+15	Oct. 19, 20	4	Swift.
718	1887	21	92	+14	...	23	Swift, streaks. Orionids.
719	1887	21	105	+52	Oct. 14, 15, 20	5	Swift, =704.

No.	Year.	Date.	Radiant. α	δ	Other Nights of Observation.	No. of Meteors.	Appearance, &c.
720	1887	Oct. 21	125	+43	Oct. 20	7	Swift, streaks.
721	1886	22	43	+ 5	...	5	Slow, short, faint, =708.
722	1878	22	91	+15	...	11	Swift, streaks. Orionids.
723	1887	24	91	+16	...	9	Swift, streaks. Orionids.
724	1876	25	61	+18	Oct. 21, 29	6	Not swift, bright, =696.
725	1885	27	213	+75	Nov. 5, 15	7	Slow, = 683.
726	1885	29	26	+72	Nov. 5, 7	5	Slow.
727	1876	29	109	+23	Oct. 25	11	Very, very swift, =752.
728	1876	29	125	+47	...	17	Swift, streaks.
729	1877	31	40	+77	...	9	Not swift, faint.
730	1877	31	43	+21	...	8	Slow, bright, = 731.
731	1877	Nov. 1	43	+23	Nov. 4, 5, 7	23	Slow, bright, trains, =730.
732	1886	2	55	+ 9	Nov. 3	17	Rather slow, bright, trains. T. 91.
733	1886	2	60	+27	Nov. 1, 3	6	Slow.
734	1886	2	97	+42	Nov. 3	5	Very swift.
735	1886	3	32	+ 8	Nov. 2	5	Small, slow, trains.
736	1886	3	38	+20	Nov. 2	5	Slow, ?=730-1.
737	1886	3	48	+21	Nov. 2	4	Rather swift, bright, ?=730-1.
738	1877	3	60	+34	Nov. 4, 5	12	Swift, =760.
739	1886	3	133	+43	...	4	Very swift, bright, streaks.

No.	Year.	Date.	Radiant. α	δ	Other Nights of Observation.	No. of Meteors.	Appearance, &c.
740	1877	Nov. 4	25	+46	Nov. 7	4	Slow.
741	1877	4	61	+49	Nov. 7, 9	8	Swift, =777.
742	1877	4	62	+9	...	6	Slowish, trains.
743	1877	4	97	+25	Nov. 7	8	Swift.
744	1877	5	19	+30	Nov. 10	7	Slow, white.
745	1877	5	45	+60	Nov. 7	6	Swift.
746	1872	6	64	+20	Nov. 9, 10	12	Slowish, ? =749, 759.
747	1876	7	17	+53	Nov. 8	7	Rather swift.
748	1877	7	30	+16	Nov. 4, 5	11	Swift.
749	1877	7	57	+18	Nov. 1, 4	9	Slowish, =753.
750	1877	7	77	+32	Nov. 9	8	Not very swift, =761.
751	1877	7	102	+73	Nov. 4, 9, 10	13	Very, very swift.
752	1877	7	110	+25	Nov. 10, 12	8	Swift, =727.
753	1876	8	58	+16	Nov. 7	3	Not swift, bright, =749.
754	1877	9	29	+37	Nov. 4, 7, 10	5	Slowish.
755	1877	9	40	+10	Nov. 4	5	Slowish.
756	1877	10	133	+31	Nov. 12	10	Swift, streaks, =803.
757	1877	10	338	+59	...	6	Swift.
758	1879	12	5	+52	Nov. 10, 13	5	Rather swift, faint.
759	1879	12	62	+21½	...	14.	Slow, =746, 768.

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No.	Year.	Date.	Radiant α	Radiant δ	Other Nights of Observation.	No. of Meteors.	Appearance, &c.
760	1879	Nov. 12	62	+34	Nov. 13, 14	4	Slowish, =738.
761	1879	12	76½	+33	Nov. 13	5	Slow, =750, 794.
762	1897	12	107	+11	Nov. 10, 11	11	Very swift,
763	1877	12	125	+40	...	5	Swift, streaks, =786.
764	1877	12	127	+17	Nov. 10	12	Swift, long.
765	1879	12	143	+69	Nov. 13	8	Swift.
766	1879	13	46	+21	Nov. 12, 14	19	Slow, trained.
767	1879	13	48	+43	Nov. 12, 14	4	Slow, ? =820.
768	1879	13	58	+21	Nov. 14	11	Slow, =759.
769	1877	13	70	+65	...	6	Not swift, =799.
770	1877	13	103	+48	Nov. 10, 12	21	Swift.
771	1879	13	124	+55	...	5	Swift, streaks.
772	1879	13	133	+70	Nov. 12	8	Swift.
773	1879	13	148	+23	Nov. 12	18	Very swift, streaks. Leonids.
774	1877	13	148	+24	Nov. 10	5	Very swift, streaks. Leonids.
775	1888	13	149	+22	...	17	Swift, bright, streaks. Leonids.
776	1879	13	191	+58	...	5	Slow, bright, white.
777	1879	14	61	+48	Nov. 13	4	Slowish, =741.
778	1887	14	65	+24	Nov. 15, 23	4	Slowish, =768, 798.
779	1879	14	80	+24	Nov. 12, 13	7	Not swift, =810.

No.	Year.	Date.	Radiant. α	Radiant. δ	Other Nights of Observation.	No. of Meteors.	Appearance, &c.
780	1885	Nov. 14	143	+50	Nov. 15, 16	6	Very swift, streaks.
781	1885	14	149	+21	...	5	Very swift, streaks. Leonids.
782	1887	14	150	+22	...	7	Swift, streaks. Leonids.
783	1887	14	194	+67	Nov. 23	7	Swift, streaks.
784	1885	15	60	+28	Nov. 14, 17	6	Slow, bright, trains.
785	1885	15	73	+42	Nov. 14	5	Swift.
786	1885	15	125	+41	Nov. 14, 16	6	Swift, streaks, =763.
787	1885	16	100	+41	Nov. 14, 15	5	Swift.
788	1885	16	150	+22	...	6	Very swift, streaks. Leonids.
789	1885	16	154	+40½	Nov. 14	12	Very swift, streaks, =815.
790	1885	16	157	+74	Nov. 14, 15	5	Slow, faint.
791	1885	16	190	+21	Nov. 17	3	Very, very swift, streaks.
792	1885	16	200	+58	Nov. 15	4	Slow, =808.
793	1886	17	53	+71	Nov. 16, 18	8	Rather swift.
794	1886	17	76	+33	...	5	Slowish, =761.
795	1885	17	79	+56	Nov. 15, 16	6	Swift.
796	1885	17	166	+31	Nov. 14, 15, 16	10	Very swift, streaks.
797	1876	19	111	+22	Nov. 20	5	Very swift.
798	1876	20	62	+22½	...	11	Slowish, bright, long, =778, 822.
799	1876	20	69	+66	Nov. 19	8	Rather slow, faint, =769.

No.	Year	Date	Radiant α	δ	Other Nights of Observation	No. of Meteors	Appearance, &c.
800	1876	Nov. 20	85	+33	...	7	Slow, orange, ?=794.
801	1876	20	149	+22	Nov. 19	5	Swift, streaks. ? Leonids.
802	1876	22	78	+43	Nov. 20, 25, 28	9	Swift, white.
803	1887	23	132	+31	Nov. 14	5	Swift, streaks, =756, 849.
804	1887	23	141	+27	Nov. 14	5	Swift, streaks.
805	1887	23	157	+49	Nov. 14	5	Swift, streaks.
806	1887	23	169	+74	Nov. 29, 1877	5	Slow.
807	1887	23	181	+25	...	3	Swift, streaks, =825.
808	1887	23	200	+56	...	4	Slowish, =792.
809	1877	25	24	+45	Nov. 27	9	Very slow, yellow, trains. Andromedes.
810	1876	25	79	+21	Nov. 22, 26	7	Not swift, =779, 823.
811	1876	25	112	+13	Nov. 26–28	7	Very swift.
812	1876	25	140	+65	Nov. 26–28	16	Very swift.
813	1885	26	26	+44	...	60	Very slow, trains. Andromedes.
814	1876	26	148	+2	Nov. 25, 27, 28	11	Very, very swift, streaks, =866.
815	1876	26	155	+36	Nov. 25, 27, 28	26	Very, very swift, streaks, =789.
816	1876	26	208	+43	Nov. 25, 27, 28	17	Swift, short.
817	1885	26	332	+58	Nov. 27	5	Slowish, white.
818	1872	27	29	+46	...	79	Very slow, small. Andromedes.
819	1885	27	24	+44	...	...	Very slow, trains. Andromedes.

No.	Year	Date	Radiant α	δ	Other Nights of Observation	No. of Meteors	Appearance, &c.
820	1877–80	Nov. 27	48	+42	Dec. 2, 4, 8	10	Slow, ?=767.
821	1877	27	54	+48	...	4	Swift, ?=840.
822	1880	27	63	+21	Nov. 28	8	Slow, bright, trains, =798, 832.
823	1880	27	78	+24	Nov. 28	5	Slowish, bright, =810.
824	1896	27	170	+4	Nov. 20, 25, 26	6	Very, very swift.
825	1896	27	179	+29	Nov. 28, 29	8	Swift, short, =807.
826	1885	28	22	+43‡	...	55	Very slow, trains, faint. Andromedes.
827	1885	28	37	−13	Dec. 1	3	Very slow, bright.
828	1876	28	212	+18	Nov. 27	7	Slowish, faint.
829	1886	29	27	+71	Nov. 30	5	Slow, short, faint, =838.
830	1886	29	44	+56	...	10	Slow, trains, =847.
831	1877	29	60	+37	Nov. 27, 29, Dec. 1	5	Slow, white, =841.
832	1886	29	64	+23	Nov. 30, Dec. 1	6	Rather slow, =822.
833	1877	29	70	+15	Nov. 27	5	Not very swift.
834	1877	29	100	+72	Dec. 1–6	4	Swift.
835	1877	29	104	+48	Nov. 30, Dec. 8	7	Swift.
836	1877	29	185	+71	Dec. 1	9	Swift, streaks.
837	1885	30	21	+42‡	...	10	Very slow, trains, faint. Andromedes.
838	1885	30	27	+71	Nov. 28, Dec. 1	6	Slow, =829, 870.
839	1885	30	41	+39	Nov. 28	6	Swift.

No.	Year	Date	Radiant α	Radiant δ	Other Nights of Observation	No. of Meteors	Appearance, &c.
840	1885	Nov. 30	60	+49	Nov. 28, Dec. 1-10	8	Very swift, ? =821.
841	1886	30	61	+37	Nov. 29	5	Slow, =831.
842	1886	30	81	+22	Nov. 29	6	Slow, =852.
843	1886	30	109	+58	Nov. 29	5	Swift.
844	1886	30	136	+77	Dec. 2, 5	5	Swift.
845	1886	30	190	+58	Nov. 18, Dec. 5	6	Swift, streaks.
846	1886	30	190	+79	Nov. 29	6	Swift.
847	1885	Dec. 1	44	+56	Dec. 9, 10	10	Slow, faint, trains, =830.
848	1885	1	194	+43	Nov. 30, Dec. 4	8	Very swift, streaks.
849	1877	2	131	+32	Dec. 8	6	Swift, streaks, =803.
850	1886	2	162	+58	Nov. 30, Dec. 2, 4, 6	6	Very swift, streaks, =873.
851	1885	4	31	+37	Nov. 30, Dec. 7	5	Very slow, trains.
852	1885	4	79	+24	Dec. 7	8	Slow, =842.
853	1885	4	105	+34	Dec. 1	8	Swift. Geminids.
854	1885	4	110	+25	Dec. 7-10	11	Slowish.
855	1885	4	143	+48⅓	Dec. 7	11	Swift, streaks.
856	1876	6	70	+67	Dec. 4, 8	6	Slowish.
857	1876	6	80	+23	Dec. 4, 8	13	Slow, bright, =852, 858.
858	1877	6	80	+25	Nov. 29, Dec. 1-8	6	Slow, =857, 890.
859	1885	7	88	+19	Nov. 30, Dec. 4, 9, 10	11	Slowish.

No.	Year.	Date.	Radiant α	δ	Other Nights of Observation.	No. of Meteors.	Appearance, &c.
860	1856	Dec. 5	105	+11	Nov. 30, Dec. 2	5	Swift.
861	1885	7	115	+33	Dec. 8	11	Not swift, =877.
862	1885	7	142	+27	Dec. 4, 9, 10	5	Very swift, streaks.
863	1877	8	87	+37	...	5	Rather swift.
864	1876	8	103	+31	Dec. 6	20	Bright, slowish. Geminids.
865	1877	8	109	+33	Dec. 6, 10	9	Swift. Geminids.
866	1877	8	145	+7	Dec. 10	8	Swift, bright, streaks, =814.
867	1876	8	208	+71	Dec. 4, 6	11	Swift, white.
868	1884	8	214	+62	...	4	Slowish.
869	1884	8	230	+85	...	4	Short, swift, faint.
870	1885	9	28	+70	Dec. 10	7	Slow, bright, trains, =838.
871	1885	9	99	+70	Dec. 1, 10	5	Swift.
872	1885	9	158	+72	Dec. 1, 10	10	Rather swift.
873	1885	9	161	+58	Dec. 4, 7	6	Very swift, =850.
874	1885	9	203	+57	Dec. 7, 8	5	Swift, white.
875	1885	10	105	+50	Dec. 9	6	Not swift.
876	1885	10	107	+33	Dec. 9	28	Swift, short. Geminids.
877	1885	10	117	+32	Dec. 9	10	Slowish, bright, =861.
878	1885	10	143	+39	Dec. 9, 11	5	Swift, streaks.
879	1885	10	152	+40	Dec. 2, 5, 7	8	Swift, streaks.

No.	Year.	Date.	Radiant α	δ	Other Nights of Observation.	No. of Meteors.	Appearance, &c.
880	1876	Dec. 12	109	+33	Dec. 11, 13	24	Slowish, bright. Geminids.
881	1877	12	166	± 0	Dec. 10, 24, 29	7	Very swift, streaks.
882	1877	12	173	+11	...	5	Swift, streaks.
883	1876	12	187	+37	...	6	Not swift.
884	1876	12	221	+53	Dec. 21	8	Rather slow, trains.
885	1876	13	79	+49	Dec. 8, 12	12	Swift, white.
886	1877	13	199	+19	Dec. 12	5	Swift, short.
887	1877–86	13	220	+14	Nov. 28, Dec. 5	6	Not very swift.
888	1877	13	221	+43	Dec. 12	4	Swift, streaks.
889	1877	13	230	+33	Dec. 12	5	Swift, short.
890	1886	18	80	+24	Dec. 15, 22, 28	6	Slow, = 858.
891	1886	18	134	+ 8	Dec. 20, 22	6	Very swift.
892	1875	19	277	+73	Dec. 23	4	Slowish.
893	1886	20	47	+65	Dec. 15, 22, 29	5	Slow, faint, trains.
894	1876	21	129	+19	...	5	Slowish, faint, = 899.
895	1876	21	165	– 6	Dec. 12	5	Very swift, streaks.
896	1886	22	194	+67	Dec. 18, 20, 24, 29	17	Swift, streaks.
897	1886	22	201	+ 4	Dec. 21, 28	4	Very swift, streaks.
898	1886	24	77	+32	Dec. 22, 28, 29	5	Slow.
899	1886	24	129	+19	Dec. 22	5	Rather swift, = 894.

No.	Year.	Date.	Radiant. α	δ	Other Nights of Observation.	No. of Meteors.	Appearance, &c.
900	1886	Dec. 24	145	+7	Dec. 20, 28, 29	5	Swift, streaks, =13.
901	1886	24	184	+39	Dec. 28	6	Very swift, streaks.
902	1886	24	207	+18	Dec. 22, 29	5	Very swift, streaks.
903	1886	24	218	+36	Dec. 22	8	Very swift, bright, streaks.
904	1886	24	248	+70	...	5	Swift, faint.
905	1886	25	98	+31	Dec. 20, 24, 28, 29	11	Very slow.
906	1886-8	28	47	+44	Jan. 2, 11	7	Very slow, trains.
907	1886	28	115	+32	Dec. 22, 24, 29	7	Slow.
908	1886	28	133	+43	Dec. 28, 29	5	Swift.
909	1886	28	177	+49	Dec. 29	5	Swift, streaks.
910	1886	28	194	+32	Dec. 18, 22, 29	7	Very swift, streaks.
911	1886	29	125	+39	Dec. 24, 28	5	Slow.
912	1886	29	168	+18	Dec. 21, 22	5	Swift, =918.
913	1886	29	231	+52	Dec. 28	5	Rather swift, long, =1.
914	1886	29	293	+70	Dec. 18, 22	5	Slow.
915	1877	31	92	+57	...	4	Slow, bright.
916	1872	31	106	+36	Jan. 4, 5, 7	10	Slow.
917	1872	31	140	+45	Jan. 8	5	Swift.
918	1872	31	164	+20	...	4	Swift, =912.

List of 45 Long-enduring and apparently Stationary Radiant Points of Shooting Stars.

(*Arranged according to R.A.*)

Ref. No.	Apparent Duration of Radiant.	Place of Radiant. a δ	Approximate Star.
1	July 11–September 22	$6 + 11$	γ Pegasi.
2	July 11–October 8	$7 + 35$	π Andromedæ.
3	August–November	$27 + 71$	ϕ Custos Messium.
4	July 27–December 7	$30 + 36\frac{1}{2}$	β Trianguli.
5	July 30–November 7	$32\frac{1}{2} + 18$	a Arietis.
6	July–January 11	$47 + 44$	β Persei.
7	July–November	$54 + 71$	H_2 Camelopardi.
8	August 2–December 8	$61 + 37$	ϵ Persei.
9	July–December	$61 + 49$	μ Persei.
10	September–December	$64 + 22$	ϵ Tauri.
11	August–February	$73 + 41$	a Aurigæ.
12	August 25–December	$74 + 14\frac{1}{2}$	11 Orionis.
13	July 23–December 31	$77 + 32$	β Tauri.
14	September–November	$77 + 56\frac{1}{2}$	ξ Aurigæ.
15	September–December	$98 + 43$	58 Aurigæ.
16	September–December	$104 + 11\frac{1}{2}$	β Canis Minoris.
17	October 15–December	$116 + 31$	a–β Geminorum.
18	September 25–January	$120 + 15$	β Cancri.
19	October 14–December 31	$130 + 20$	δ Cancri.
20	November–February 1	$132 + 31$	ι Cancri.
21	October 17–December 29	$134 + 8$	ζ Hydræ.
22	November–February	$134 + 68$	σ Ursæ Majoris.
23	October 15–January 11	$141 + 28$	κ Leonis.
24	October–April	$142 + 49$	θ Ursæ Majoris.
25	November 26–February 27	$145 + 7$	o Leonis.
26	September–December	$154 + 40\frac{1}{2}$	μ Ursæ Majoris.
27	Nov.–Dec. and Mar.–Apr.	$161 + 58$	β Ursæ Majoris.
28	November 14–January 19	$167 + 4$	τ Leonis.
29	November 7–April 13	$175 + 10$	β Leonis.
30	Oct.–Nov. and April	$190 + 58$	ϵ Ursæ Majoris.
31	Nov., Dec., and Jan.	$221 + 14$	ζ Boötis.
32	January–May	$227 - 3$	β Libræ.
33	January–May	$235 + 10\frac{1}{3}$	a Serpentis.
34	Jan.–May and Sept.	$253 + 55\frac{1}{2}$	μ Draconis.
35	January–June	$261 + 4\frac{1}{2}$	β Ophiuchi.
36	Whole year	$262 + 63$	ζ Draconis.

Ref. No.	Apparent Duration of Radiant.	Place of Radiant. α δ	Approximate Star.
37	March–September	$272 + 21\frac{1}{2}$	102 Herculis.
38	February–August	$281 - 13$	λ Aquilæ.
39	April–August	296 ± 0	η Aquilæ.
40	April–September	$302 + 23\frac{1}{2}$	17 Vulpeculæ.
41	March–October	$313 + 77$	κ Cephei.
42	May 13–August 13	$314 + 15$	γ Delphini.
43	March–September	$315 + 49$	α Cygni.
44	July–Sept., Nov. and Jan.	$334 + 58$	δ Cephei.
45	June–December	346 ± 0	β Piscium.

Bristol : 1889 *October* 4.

Ephemeris for Physical Observations of the Moon.   By A. Marth.
1890 July 1 to December 31.

Greenwich Noon.	Selenographical Colong.	Lat. of the Sun.	Sel. Long.	Lat. of the Earth.	Combined Amount.	Direction.
			Geocentric Libration.			
1890. July 1	$78 \overset{\circ}{\cdot} 85$	$+ 0 \overset{\circ}{\cdot} 44$	$- 4 \overset{\circ}{\cdot} 13$	$+ 0 \overset{\circ}{\cdot} 07$	$4 \overset{\circ}{\cdot} 13$	$89 \overset{\circ}{\cdot} 1$
2	91·04	·47	2·46	1·82	3·06	53·6
3	103·23	·50	−0·60	3·46	3·51	9·8
4	115·42	·53	+1·31	4·86	5·04	344·9
5	127·62	·55	3·13	5·92	6·70	332·2
6	139·82	+0·58	+4·72	+6·57	8·09	324·4
7	152·03	·61	5·98	6·80	9·04	318·9
8	164·24	·63	6·83	6·60	9·49	314·2
9	176·46	·66	7·27	6·02	9·43	309·8
10	188·68	·68	7·31	5·15	8·94	305·3
11	200·91	·70	7·00	4·03	8·07	300·1
12	213·15	·72	6·37	2·74	6·94	293·4
13	225·39	+0·74	+5·50	+1·35	5·67	283·8
14	237·64	·76	4·44	−0·08	4·45	269·0
15	249·89	·78	3·25	1·49	3·58	245·4
16	262·14	·80	1·96	2·82	3·44	214·9
17	274·39	·82	+0·63	4·02	4·07	188·9
18	286·64	·84	−0·72	5·04	5·09	171·9
19	298·89	·86	2·05	5·85	6·19	160·7
20	311·14	+0·88	−3·33	−6·40	7·22	152·6
21	323·38	·90	4·52	6·68	8·07	146·1
22	335·62	·92	5·58	6·67	8·69	140·3

Greenwich Noon.	Selenographical Colong. | Lat. of the Sun.		Geocentric Libration. Sel. Long. | Lat. of the Earth.		Combined Amount.	Direction.
1890. July 23	347·85	+0·95	−6·45	−6·36	9·05	134·7
24	0·08	·97	7·09	5·74	9·10	129·2
25	12·30	0·99	7·43	4·82	8·85	123·1
26	24·51	1·01	7·41	3·62	8·24	116·1
27	36·72	+1·04	−6·98	−2·18	7·32	107·4
28	48·92	1·06	6·12	−0·56	6·14	95·3
29	61·11	1·08	4·81	+1·13	4·95	76·8
30	73·30	1·11	3·12	2·79	4·19	48·2
31	85·49	1·13	−1·15	4·29	4·44	14·9
Aug. 1	97·67	1·15	+0·97	5·48	5·57	350·1
2	109·86	1·17	3·04	6·29	6·98	334·3
3	122·05	+1·19	+4·88	+6·64	8·24	323·8
4	134·24	1·21	6·36	6·56	9·13	314·0
5	146·44	1·22	7·38	6·06	9·54	309·6
6	158·65	1·24	7·89	5·24	9·46	303·7
7	170·86	1·25	7·93	4·15	8·94	297·7
8	183·08	1·27	7·54	2·89	8·07	291·0
9	195·30	1·28	6·80	1·52	6·97	282·6
10	207·53	+1·29	+5·80	+0·13	5·80	271·3
11	219·76	1·30	4·60	−1·28	4·78	254·5
12	232·00	1·31	3·30	2·60	4·19	231·7
13	244·24	1·32	1·94	3·80	4·26	207·0
14	256·48	1·33	+0·57	4·83	4·86	186·8
15	268·73	1·34	−0·75	5·65	5·70	172·4
16	280·97	1·36	2·02	6·23	6·54	162·1
17	293·21	+1·37	−3·20	−6·54	7·27	154·0
18	305·45	1·38	4·27	6·56	7·82	147·0
19	317·69	1·39	5·22	6·28	8·16	140·4
20	329·92	1·40	6·02	5·70	8·28	133·6
21	342·15	1·41	6·62	4·85	8·20	126·4
22	354·37	1·43	6·99	3·74	7·92	118·3
23	6·58	1·44	7·05	2·40	7·45	108·9
24	18·79	+1·45	−6·77	−0·90	6·83	97·6
25	30·99	1·46	6·08	+0·70	6·12	83·4
26	43·18	1·47	4·99	2·31	5·49	65·1
27	55·36	1·48	3·48	3·80	5·15	42·4
28	67·54	1·49	−1·64	5·06	5·32	17·9

Greenwich Noon.	Selenographical Colong.	Lat. of the Sun.	Sel. Long. of the Earth.	Lat.	Combined Amount.	Direction.
1890.	°	°	°	°		°
Aug. 29	79·72	+ 1·50	+ 0·40	+ 5·98	5·99	356·2
30	91·90	1·51	2·48	6·48	6·93	339·2
31	104·07	+ 1·52	+ 4·38	+ 6·52	7·85	326·2
Sept. 1	116·25	1·52	5·96	6·12	8·53	316·0
2	128·43	1·53	7·08	5·35	8·86	307·3
3	140·62	1·53	7·69	4·29	8·80	299·3
4	152·81	1·53	7·79	3·03	8·35	291·3
5	165·01	1·53	7·43	1·65	7·61	282·5
6	177·21	1·53	6·70	+ 0·23	6·70	272·0
7	189·42	+ 1·53	+ 5·67	− 1·17	5·78	258·3
8	201·63	1·53	4·44	2·49	5·09	240·7
9	213·85	1·53	3·10	3·69	4·82	220·1
10	226·07	1·53	1·74	4·72	5·03	200·2
11	238·29	1·52	+ 0·40	5·55	5·56	184·1
12	250·52	1·52	− 0·87	6·14	6·20	171·9
13	262·75	1·52	2·01	6·47	6·77	162·8
14	274·98	+ 1·52	− 3·04	− 6·51	7·18	155·1
15	287·21	1·52	3·93	6·25	7·38	147·9
16	299·44	1·52	4·68	5·69	7·36	140·7
17	311·67	1·52	5·28	4·87	7·18	132·8
18	323·89	1·52	5·71	3·76	6·83	123·4
19	336·10	1·52	5·97	2·45	6·45	112·4
20	348·31	1·51	5·97	− 0·99	6·06	99·5
21	0·51	+ 1·51	− 5·72	+ 0·55	5·83	84·5
22	12·71	1·51	5·16	2·10	5·57	67·8
23	24·90	1·51	4·26	3·56	5·55	50·0
24	37·06	1·51	3·02	4·83	5·69	32·0
25	49·25	1·50	− 1·49	5·80	5·99	14·4
26	61·42	1·50	+ 0·24	6·39	6·40	357·8
27	73·58	1·49	2·04	6·55	6·86	342·8
28	85·74	+ 1·48	+ 3·73	+ 6·27	7·28	329·4
29	97·90	1·47	5·17	5·59	7·61	317·3
30	110·06	1·46	6·23	4·56	7·72	306·3
Oct. 1	122·22	1·45	6·84	3·30	7·59	295·8
2	134·39	1·44	6·97	1·89	7·22	285·2
3	146·56	1·42	6·67	+ 0·42	6·68	273·7
4	158·74	1·41	5·98	− 1·02	6·06	260·3

Greenwich Noon. 1890.	Selenographical Colong.	Lat. of the Sun.	Geocentric Libration. Sel. Long.	Lat. of the Earth.	Combined Amount.	Direction.
Oct. 5	170·93	+1·39	+4·99	−2·39	5·53	244·4
6	183·12	1·38	3·80	3·62	5·25	226·3
7	195·31	1·36	2·49	4·68	5·31	208·0
8	207·51	1·35	+1·15	5·54	5·66	191·7
9	219·71	1·34	−0·14	6·16	6·17	178·8
10	231·92	1·32	1·32	6·52	6·65	168·6
11	244·13	1·31	2·36	6·59	7·00	160·4
12	256·35	+1·29	+3·22	−6·37	7·13	153·3
13	268·56	1·28	3·89	5·83	7·00	146·4
14	280·78	1·27	4·37	4·99	6·63	138·9
15	292·99	1·25	4·67	3·90	6·08	129·9
16	305·20	1·24	4·79	2·58	5·44	118·3
17	317·41	1·23	4·74	−1·10	4·87	103·0
18	329·61	1·21	4·51	+0·46	4·54	84·1
19	341·81	+1·20	−4·09	+2·02	4·56	63·6
20	354·00	1·19	3·47	3·49	4·92	44·8
21	6·18	1·17	2·64	4·77	5·45	28·9
22	18·35	1·15	1·59	5·77	5·99	15·4
23	30·52	1·13	−0·38	6·42	6·45	3·4
24	42·68	1·12	+0·94	6·67	6·74	352·0
25	54·83	1·10	2·29	6·50	6·89	340·7
26	66·98	+1·07	+3·55	+5·92	6·89	329·2
27	79·13	1·05	4·61	4·97	6·77	317·3
28	91·27	1·03	5·38	3·74	6·55	304·9
29	103·42	1·00	5·80	2·32	6·25	291·9
30	115·57	0·98	5·85	+0·81	5·90	277·9
31	127·72	·95	5·52	−0·70	5·56	262·8
Nov. 1	139·87	·93	4·84	2·14	5·30	246·1
2	152·03	+0·90	+3·90	−3·45	5·20	228·4
3	164·19	·87	2·76	4·59	5·35	210·9
4	176·36	·85	1·49	5·51	5·71	195·1
5	188·54	·82	+0·19	6·19	6·19	181·7
6	200·72	·80	−1·08	6·61	6·70	170·7
7	212·90	·77	22	6·74	7·10	161·9
8	225·09	·75	3·19	6·58	7·31	154·2
9	237·29	+0·73	−3·95	−6·11	7·26	147·2
10	249·49	·71	4·45	5·33	6·94	140·2
11	261·69	·68	4·69	4·26	6·33	132·4

Greenwich Noon. 1890.	Selenographical Colong.	Lat. of the Sun.	Sel. Long.	Geocentric Libration. Lat. of the Earth.	Combined Amount.	Direction.
Nov. 12	273·89	+0·66	−4·67	−2·94	5·51	122·3
13	286·09	·64	4·40	−1·44	4·63	108·1
14	298·29	·62	3·93	+0·17	3·93	87·5
15	310·48	·60	3·27	1·80	3·73	61·2
16	322·67	+0·57	−2·47	+3·33	4·15	36·5
17	334·86	·55	1·55	4·68	4·92	18·2
18	347·04	·52	−0·56	5·74	5·77	5·5
19	359·21	·50	+0·48	6·46	6·48	355·8
20	11·37	·47	1·51	6·78	6·95	347·5
21	23·53	·44	2·51	6·69	7·14	339·6
22	35·68	·42	3·41	6·20	7·07	331·3
23	47·82	+0·39	+4·16	+5·35	6·78	322·3
24	59·96	·36	4·72	4·20	6·31	311·8
25	72·09	·32	5·05	2·83	5·78	299·3
26	84·22	·29	5·11	+1·33	5·28	284·6
27	96·36	·26	4·90	−0·21	4·91	267·5
28	108·49	·23	4·42	1·69	4·73	249·1
29	120·63	·20	3·68	3·10	4·81	229·8
30	132·77	+0·16	+2·72	−4·32	5·11	212·2
Dec. 1	144·91	·13	1·60	5·33	5·56	196·6
2	157·06	·10	+0·36	6·09	6·10	183·3
3	169·21	·07	−0·93	6·59	6·64	172·0
4	181·37	·04	2·19	6·81	7·15	162·3
5	193·54	+0·02	3·35	6·74	7·52	153·7
6	205·71	−0·01	4·34	6·36	7·70	145·8
7	217·88	−0·04	−5·09	−5·69	7·63	138·3
8	230·06	·07	5·55	4·72	7·28	130·5
9	242·25	·09	5·68	3·48	6·66	121·6
10	254·44	·12	5·45	2·02	5·82	110·4
11	266·63	·14	4·88	−0·41	4·89	94·8
12	278·82	·16	3·99	+1·27	4·18	72·4
13	291·01	·19	2·85	2·89	4·06	44·5
14	303·20	−0·21	−1·53	+4·35	4·62	19·8
15	315·39	·24	−0·14	5·53	5·53	1·4
16	327·57	·26	+1·23	6·35	6·47	349·0
17	339·74	·29	2·50	6·76	7·21	339·8
18	351·90	·32	3·59	6·75	7·65	332·1

| Greenwich Noon. | Selenographical | | Sel. Long. of the Earth. | Geocentric Libration. | | Direction. |
	Colong. of the Sun.	Lat.		Lat.	Combined Amount.	
1890.	°	°		°		°
Dec. 19	4·06	−0·35	+4·45	+6·34	7·74	325·1
20	16·21	·38	5·07	5·57	7·52	317·8
21	28·36	−0·41	+5·43	+4·50	7·04	309·8
22	40·50	·44	5·54	3·20	6·39	300·1
23	52·63	·47	5·41	1·75	5·69	288·0
24	64·76	·50	5·07	+0·25	5·08	272·8
25	76·89	·53	4·53	−1·26	4·70	254·4
26	89·02	·56	3·80	2·67	4·64	234·8
27	101·15	·59	2·90	3·94	4·89	216·3
28	113·28	−0·62	+1·86	−5·01	5·35	200·3
29	125·41	·65	+0·70	5·85	5·89	186·8
30	137·54	·68	−0·55	6·42	6·45	175·2
31	149·68	−0·70	−1·83	−6·72	6·96	164·8

Errata in Vol. II. of Oppolzer's Lehrbuch zur Bahnbestimmung.
By Lieut.-General J. F. Tennant, R.E., F.R.S.

I have found the following errors in addition to the extended list issued subsequently to the publication of the work.

Page 11. Formula 16. For $C^{d-p}\{1, 2, 3 \ldots d-1\}$, read
$$C^{d-p}\{1^2, 2^2, 3^2 \ldots (d-1)^2\}.$$

15. Line 7 from bottom. For $mf\{a+(i+\frac{1}{2})w\}$, read $mf^1\{a+(i+\frac{1}{2})w\}$.

32. Line 8 from bottom, in dl after $l(a+[i+n]w)$, for $+$ read $=$.

41. Formula 15. In the limits of integration, for $a+(i+\frac{1}{2}m)$, read $a+(i+\frac{1}{2})m$.

108. Line 2 from bottom. For $\frac{h}{24}f(a)+$, read $\frac{1}{24}f(a)-$.

148. Line 1. For $(\nu)^2$, read $((\nu))^2$.

150. Line 3 from bottom. For $\tau't$, read τ'.

151. Line 7 from bottom. For $(12\gamma - aa)$, read $(12\gamma + aa)$.

163. Line in formula for β. For $\dfrac{\sin \frac{1}{2}(E-E_0)}{\frac{1}{2}(E-E_0)}$, read $\dfrac{\sin \frac{1}{2}(E-E_0)}{\frac{1}{2}(E-E_0)\sin 1''}$.

I may mention also that there seem to be errors in the figures of the computations from careless reading, thus:—

Page 110. Log. $S_{(x)}$	for Oct. 27	should be	2_n·861612	instead of	1_n·861612.
„ $S_{(z)}$	„ Dec. 6	„	0_n·075547	„	0_n·045547.
111. Log. fq	„ Feb. 24	„	2·328069	„	2·308069.
fqx	„ Dec. 6	„	2_n·028385	„	2·128385.
fqz	„ Oct. 27	„	1·732151	„	1·733151.
$\Delta\Sigma(z)$	„ Oct. 27	„	−0·62	„	−0·00

Erratum.

Vol. L., page 353, line 12 from bottom, *for* " *Berliner* " *read* " *Nautisches.* "

Lieut.-General J. F. TENNANT, C.I.E., R.E., F.R.S., President,
in the Chair.

Thomas Steele Sheldon, M.B.Lond., Parkside, Macclesfield,
was balloted for and duly elected a Fellow of the Society.

The following candidate was proposed for election as a
Fellow of the Society, the name of the proposer from personal
knowledge being appended :—

Rev. John Mitchell, B.D., 57 Parkgate Road, Chester (pro-
posed by John Hartnup).

The following were proposed by the Council as Associates
of the Society :—

Lewis Boss, Dudley Observatory, Albany, N.Y., U.S.A. ;
A. Cornu, Paris ;
C. Souillart, Lille, France.

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*Comparison of the Right Ascensions of Clock Stars in the
Greenwich Ten-Year Catalogue for 1880 with the Fundamental
Catalogues of the American Ephemeris and of the Astrono-
mische Gesellschaft.* By Professor Simon Newcomb.

The fundamental catalogues with which this comparison is
made are found in the following three publications :—

(a) *Catalogue of* 1098 *Standard Clock and Zodiacal Stars;
Astronomical Papers of the American Ephemeris,* vol. i.

(b) *Fundamental-Catalog für die Zonen-Beobachtungen am
nordlichen Himmel. Herausgegeben im Auftrage der Zonen-Com-*

mission der Astronomischen Gesellschaft, von A. Auwers. Pub.
XIV. *der Astronomischen Gesellschaft.*

(c) *Vorläufiger Fundamental-Catalog für die südlichen Zonen
der Astronomischen Gesellschaft.* Von A. Auwers. *Ast. Nachr.*
No. 2890, vol. cxxi. p. 145.

I have ignored the preliminary fundamental catalogue given
in Publication XVII., *Astronomische Gesellschaft,* supposing it to
be superseded by the last catalogue (c) just quoted. And I have
devoted a separate column to the latter because it gives revised
positions of a few stars of (b).

The latest Greenwich observations employed in these funda-
mental catalogues were those for the year 1876. Such at least is
the case for the first two, and I infer the same to be true of the
last, because later Greenwich observations are not mentioned in
the list of authorities on which it rests. The observations on
which the Ten-Year Catalogue was formed began in 1877, so
that its results are quite independent of the catalogues compared.
Some interest may therefore attach to a comparison of the
authorities, as affording an index to the degree of precision
attained in the right ascension of fundamental stars, and sug-
gesting special points to be attended to in still further improving
these right ascensions. In the following exhibit the second
column contains the right ascensions, given on pp. 56 and 57
of the Ten-Year Catalogue, as based on 12-hour groups. The
three following columns (a, b, c) contain the decimals of the
seconds of right ascension from the three fundamental catalogues,
taken in order. In each case the positions for 1880·0 have
been derived from those of the catalogue by using the values of
the proper motions given therein.

The three following columns contain the apparent corrections
in right ascension given by the Greenwich results :—

Name of Star.	Right Ascensions for 1880·0.				App. Corrections.		
	Ten-Year Cat.	(a)	(b)	(c)	(a)	(b)	(c)
	h m s	s	s				
α Androm.	0 2 11·186	·210	202	...	−24	−16	...
γ Pegasi	0 7 3·408	·455	·449	...	−47	−41	...
ι Ceti	0 13 18·801	...	·812	·804	...	−11	−3
44 Piscium	0 19 15·070	·079	...	...	−9	...	...
12 Ceti	0 23 54·846	·878	...	·894	−32	...	−48
ε Androm.	0 32 12·961	...	·993	...	...	−32	...
β Ceti	0 37 33·904	·947	...	·918	−43	...	−14
δ Piscium	0 42 27·397	·419	...	...	−22	...	...
20 Ceti	0 46 52·483	·483	...	...	0	...	...
μ Androm.	0 50 5·711	...	·826	...	...	−115	...
ε Piscium	0 56 42·932	·952	·956	...	−20	−24	...
β Androm.	1 3 0·932	·996	ʋ01	...	−64	−69	...
ζ¹ Piscium	1 7 27·711	·717	...	...	−6	...	...

Name of Star.	Ten-Year Cat.	(a)	(b)	(c)	(a)	(b)	(c)
	h m s	s					
θ Ceti	1 18 1·479	·519	·544	·532	−40	−65	−53
η Piscium	1 25 3·758	·805	·796	...	−47	−38	...
ν Piscium	1 35 11·195	·234	...	·216	−39	...	−21
o Piscium	1 39 3·432	·477	·456	...	−45	−24	...
β Arietis	1 48 0·727	·762	·760	...	−35	−33	...
α Arietis	2 0 24·611	·646	·640	...	−35	−29	...
ξ¹ Ceti	2 6 38·408	·452	...	...	−44	...	...
67 Ceti	2 10 59·876	...	...	·901	...	...	−25
ξ² Ceti	2 21 46·754	·806	·787	...	−52	−33	...
ν Ceti	2 29 34·633	...	...	...	...	...	...
δ Ceti	2 33 19·903	...	·951	·926	...	−48	−23
γ² Ceti	2 37 4·961	·998	·002	...	−37	−41	...
σ Arietis	2 44 52·081	·122	...	...	−41	...	...
ε Arietis	2 52 21·081	·126	...	...	−45	...	...
α Ceti	2 56 0·412	·440	·420	·424	−28	− 8	− 12
δ Arietis	3 4 46·086	·113	...	...	−27	...	...
τ¹ Arietis	3 14 18·005	·055	...	...	−50	...	...
o Tauri	3 18 21·349	...	·394	...	...	−45	...
ƒ Tauri	3 24 14·890	·921	·930	...	−31	−40	...
ε Eridani	3 27 16·603	·626	·622	·642	−23	−19	−39
11 Tauri	3 33 36·336	·361	...	...	−25	...	...
δ Eridani	3 37 29·996	...	...	·020	...	...	−24
η Tauri	3 40 21 148	·149	·160	...	− 1	− 12	...
γ¹ Eridani	3 52 25·847	·887	...	·848	−40	...	− 1
A¹ Tauri	3 57 36·109	·144	...	...	−35	...	...
ω¹ Tauri	4 2 10·550	·586	...	...	−36	...	...
o¹ Eridani	4 6 0·437	...	...	·481	...	...	−44
γ Tauri	4 12 57·876	·924	·913	...	−48	−37	...
ε Tauri	4 21 36·570	·619	·626	...	−49	−56	...
Aldebaran	4 29 2·111	·144	·124	...	−33	−13	...
τ Tauri	4 35 2·592	·609	...	...	−17	...	...
μ Eridani	4 39 30·125	...	·138	·146	...	−13	−21
ι Aurigæ	4 49 10 753	·815	·822	...	−62	−69	...
ε Leporis	5 0 22·861	...	...	·890	...	...	−29
Rigel *	5 8 46·253	·267	·256	·218	−14	− 3	(+35)
β Tauri	5 18 42·382	·407	·398	...	−25	−16	...
δ Orionis	5 25 52·519	·577	·554	...	−58	−35	...

* Probably there is a typographic error in (c).

Name of Star.	Right Ascensions for 1880·0.				App. Corrections.		
	Ten-Year Cat.	(a)	(b)	(c)	(a)	(b)	(c)
	h m s	s					
a Leporis	5 27 26·260	·272	...	·267	−12	...	− 7
ε Orionis	5 30 7·444	·471	·449	·466	−27	− 5	−22
a Columbæ	5 35 18·225	·286	...	...	−61	...	...
κ Orionis	5 42 3·905	...	·898	·900	...	+ 7	+ 5
a Orionis	5 48 40·505	·516	·504	...	−11	+ 1	...
1 Geminor.	5 56 49·502	·550	...	...	−48	...	...
ν Orionis	6 0 43·184	·271	...	...	−87	...	...
η Geminor.	6 7 38·018	·072	·052	...	−54	−34	...
μ Geminor.	6 15 41·995	·059	·042	...	−64	−47	...
β Canis Maj.	6 17 24·883	...	...	·915	...	...	−32
ν Geminor.	6 21 50·238	·259	...	...	−21	...	...
γ Geminor.	6 30 46·733	·768	·771	...	−35	−38	...
ξ Geminor.	6 38 33·222	...	·242	...	...	−20	...
θ Can. Maj.	6 48 36·824	...	...	·892	...	...	−68
ε Can. Maj.	6 53 54·563	·612	...	...	−49	...	...
ζ Geminor.	6 56 59·424	·496	·476	...	−72	−52	...
γ Can. Maj.	6 58 19·738	...	...	·771	...	...	−33
51 Geminor.	7 6 28·770	·774	...	...	− 4	...	...
δ Geminor.	7 12 57·306	·337	·320	...	−31	−14	...
β Can. Min.	7 20 38·533	...	·564	...	...	−31	...
Castor	7 26 56·497	·542	...	...	−45	...	...
Procyon	7 33 1·109	·185	·139	·107	−76	−30	+ 2
Pollux	7 37 58·265	·298	·289	...	−33	−24	...
ξ Argûs	7 44 14·861	...	...	...	...	...	...
6 Cancri	7 56 8·739	·808	...	...	−69	...	...
15 Argûs	8 2 25·981	·026	...	·025	−45	...	−44
β Cancri	8 10 0·367	...	·402	...	...	−35	...
d¹ Cancri	8 16 29·477	·486	...	...	− 9	...	...
η Cancri	8 25 46·042	·105	...	...	−63	...	...
γ Cancri	8 36 20·411	·420	...	...	− 9	...	...
ε Hydræ	8 40 25·214	·247	·230	...	−33	−16	...
a Cancri	8 51 55·415	·395	·382	...	+20	+33	...
κ Cancri	9 1 14·774	·827	...	...	−53	...	...
83 Cancri	9 12 16·940	·965	...	...	−25	...	...
a Hydræ	9 21 41·398	·433	·432	·410	−35	−34	−12
ξ Leonis	9 25 28·588	·594	...	...	− 6	...	...
ε Leonis	9 34 44·690	·709	·725	...	−19	−35	...
ε Leonis	9 39 2·269	·273	·278	...	− 4	− 9	...

Name of Star.	Ten-Year Cat.	Right Ascensions for 1880·0.			App. Corrections.		
	h m s	(a) s	(b)	(c)	(a)	(b)	(c)
μ Leonis	9 45 56·170	·211	·206	...	−41	−36	...
π Leonis	9 53 52·267	·282	...	...	−15	...	...
Regulus	10 1 58·798	·818	·804	...	−20	− 6	...
γ¹ Leonis	10 13 21·284	·315	...	...	−31	...	...
μ Hydræ	10 20 17 196	...	...	·234	...	...	−38
ρ Leonis	10 26 29·475	·538	·522	...	−63	−47	...
34 Sextantis	10 36 25·649	·652	...	...	− 3	...	...
l Leonis	10 42 56·905	·956	...	...	−51	...	...
d Leonis	10 54 21·760	·759	...	...	+ 1	...	...
χ Leonis	10 58 49·610	·596	...	...	+14	...	...
δ Leonis	11 7 43·496	·513	·513	...	−17	−17	...
δ Crateris	11 13 20·488	·534	...	·504	−46	...	−16
τ Leonis	11 21 45·949	·952	...	...	− 3	...	...
υ Leonis	11 30 48·259	·290	...	...	−31	...	...
β Leonis	11 42 56·273	·288	·278	...	−15	− 5	...
β Virginis	11 44 26·668	·661	·646	·652	+ 7	+22	+16
π Virginis	11 54 43·388	·392	...	...	− 4	...	...
o Virginis	11 59 5·747	·762	·784	...	−15	−37	...
ε Corvi	12 3 57·245	...	...	·288	...	...	−43
η Virginis	12 13 45·967	·015	·996	·996	−48	−29	−29
δ² Corvi	12 23 39·354	...	...	·376	...	...	−22
β Corvi	12 28 5·131	·139	...	·125	− 8 ·	...	+ 5
ρ Virginis	12 35 48·629	...	...	...	...	...	...
35 Virginis	12 41 44·799	...	...	...	...	...	...
31 Comæ	12 45 51·153	...	...	...	...	...	...
δ Virginis	12 49 33·524	...	·524	·520	...	o	+ 4
ε Virginis	12 56 12·174	...	·208	...	...	−34	...
θ Virginis	13 3 44·247	·242	...	·244	+ 5	...	+ 3
Spica	13 18 52·296	·334	...	·348	−38	...	−52
ζ Virginis	13 28 34·719	·747	·734	·729	−28	−15	−10
m Virginis	13 35 18·844	·889	...	·890	−45	...	−46
τ Bootis	13 41 33·563	...	·594	...	...	−31	...
η Bootis	13 48 58·230	·270	·266	...	...	−36	...
τ Virginis	13 55 32·364	...	·386	·391	...	−22	−27
94 Virginis	13 59 56·570	·533	...	...	+37	...	...
κ Virginis	14 6 29·706	·754	·745	·723	−48	−39	−17
Arcturus	14 10 11·285	·306	·296	...	−21	−11	...
f Bootis	14 20 52·459	...	...	...	...	...	...

Name of Star.	Right Ascensions for 1880·0.				App. Corrections.		
	Ten-Year Cat.	(a)	(b)	(c)	(a)	(b)	(c)
	h m s	s	s				
ρ Bootis	14 26 39·478	·546	·506	...	−68	−28	...
ε² Bootis	14 39 44·758	·829	...	...	−71	...	...
α Libræ	14 44 14·470	·474	...	·480	−4	...	−10
ξ² Libræ	14 50 15·460	·488	...	·476	−28	...	−16
ψ Bootis	14 59 18·194	...	...	...	...	...	...
ι¹ Libræ	15 5 22·945	...	...	·948	...	...	−3
β Libræ	15 10 33·010	·041	·038	·028	−31	−28	−18
o² Libræ	15 16 20·262	·269	...	...	−7	...	...
ζ¹ Libræ	15 21 29·407	·422	...	·408	−15	...	−1
α Coronæ	15 29 36·415	·463	·450	...	−48	−35	...
α Serpentis	15 38 21·424	·473	·462	...	−49	−38	...
ε Serpentis	15 44 50·053	·101	·068	·080	−48	−15	−27
γ Serpentis	15 50 54·622	...	·638	...	...	−16	...
β¹ Scorpii	15 58 27·629	·670	...	·630	−41	...	−1
δ Ophiuchi	16 8 3·422	·470	·455	·454	−48	−33	−32
γ Herculis	16 16 37·590	...	·590	...	...	0	...
Antares	16 22 3·021	·072	...	·067	−51	...	−46
λ Ophiuchi	16 24 51·671	...	·698	...	...	−27	...
ζ Ophiuchi	16 30 33·074	·116	...	·090	−42	...	−16
ζ Herculis	16 36 45·735	...	·803	...	...	−68	...
κ Ophiuchi	16 51 59·282	·332	·301	...	−50	−19	...
ε Herculis	16 55 41·902	...	·928	...	...	−26	...
η Ophiuchi	17 3 29·781	·789	...	·787	−8	...	−6
α¹ Herculis	17 9 10·533	·572	·562	...	−39	−29	..
θ Ophiuchi	17 14 38·432	·433	...	...	−1	...	...
σ Ophiuchi	17 20 33·631	...	...	...	...	...	...
α Ophiuchi	17 29 21·844	·872	·862	...	−28	−18	...
β Ophiuchi	17 37 32·661	...	·674	·682	...	−13	−21
μ Herculis	17 41 45·700	·777	·774	...	−77	−74	...
89 Herculis	17 50 34·739	...	...	...	...	...	...
72 Ophiuchi	18 1 39·623	...	·633	...	...	−10	...
μ Sagittarii	18 6 35·189	·232	...	·224	−43	...	−35
η Serpentis	18 15 6·023	·053	·030	·052	−30	−7	−29
λ Sagittarii	18 20 33·875	·892	...	...	−17	...	...
α Lyræ	18 32 52·501	·553	·548	...	−52	−47	...
2 Aquilæ	18 35 42·171	...	...	...	...	...	...
β¹ Lyræ	18 45 38·958	·996	·992	...	−38	−34	...
ε Aquilæ	18 54 10·542	...	·589	...	...	−47	...

Name of Star.	Right Ascensions for 1880·0.				App. Corrections.		
	Ten-Year Cat.	(a)	(b)	(c)	(a)	(b)	(c)
	h m s	s					
ζ Aquilæ	18 59 53·667	·696	·676	...	− 29	− 9	...
ψ Sagittarii	19 8 10·883	·904	...	...	− 21	...	...
ω Aquilæ	19 12 11·008	...	...	...	...	...	...
δ Aquilæ	19 19 26 837	·875	·874	·868	− 38	− 37	− 31
a Vulpec.	19 23 42·712	...	...	...	...	...	...
μ Aquilæ	19 28 13·599	...	...	...	...	...	...
h² Sagittarii	19 29 24·222	·218	...	·239	+ 4	...	− 17
e¹ Sagittarii	19 33 50·880	·861	...	...	+ 19	...	...
γ Aquilæ	19 40 33·255	·287	·274	...	− 32	− 19	...
a Aquilæ	19 44 55·671	·710	·697	...	− 39	− 26	...
β Aquilæ	19 49 25·072	·131	·114	...	− 59	− 42	...
c Sagittarii	19 55 16·657	·684	...	...	− 27	...	...
θ Aquilæ	20 5 6·752	...	·758	·776	...	− 6	− 24
a² Capricor.	20 11 23·744	·756	...	·754	− 12	...	− 10
β Capricor.	20 14 16·093	·105	...	·074	− 12	...	+ 19
ρ Capricor.	20 22 0·859	·9c9	...	·868	− 50	...	− 9
ε Delphini	20 27 28·774	·819	·798	...	− 45	− 24	...
a Delphini	20 34 3·844	...	·857	...	...	− 13	...
ε Aquarii	20 41 10·755	...	·759	·762	...	− 4	− 7
μ Aquarii	20 46 10·808	·853	...	...	− 45	...	...
32 Vulpec.	20 49 26·747	...	...	...	...	...	...
θ Capricor.	20 59 11·986	·073	...	...	− 87	...	...
ζ Cygni	21 7 49·762	·751	·760	...	+ 11	+ 2	...
a Equulei	21 9 49·486	...	·496	·498	...	− 10	− 12
ι Capricor.	21 15 33·817	·819	...	...	− 2	...	...
β Aquarii	21 25 14·435	·479	·470	·466	− 44	− 35	− 31
ξ Aquarii	21 31 21·774	·809	...	...	− 35	...	...
ε Pegasi	21 38 17·512	·558	·544	...	− 46	− 32	...
δ Capricor.	21 40 24·968	·025	...	...	− 57	...	...
16 Pegasi	21 47 36·136	...	...	...	...	...	...
a Aquarii	21 59 37·199	·218	·205	·220	− 19	− 6	− 21
ι Pegasi	22 1 25·506	...	·521	...	...	− 15	...
θ Aquarii	22 10 30·035	·056	...	·047	− 21	...	− 12
γ Aquarii	22 15 27·462	...	·472	·478	...	− 10	− 16
σ Aquarii	22 24 17·755	·730	...	·762	+ 25	...	− 7
η Aquarii	22 29 11·366	·394	·387	·390	− 28	− 21	− 24
ζ Pegasi	22 35 28·632	·659	·651	...	− 27	− 19 .	...
μ Pegasi	22 44 12·730	...	·746	...	...	− 16	...

Name of Star.	Right Ascensions for 1880·0.				App. Corrections.		
	Ten-Year Cat.	(a)	(b)	(c)	(a)	(b)	(c)
	h m s	s			s		
λ Aquarii	22 46 21·205	·240	·204	·208	− 35	+ 1	− 3
Fomalhaut	22 51 1·005	·024	...	...	− 19	...	...
α Pegasi	22 58 47·025	·048	·032	...	− 23	− 7	...
γ Piscium	23 10 56·660	...	·661	·656	...	− 1	+ 4
κ Piscium	23 20 46·842	·852	...	·870	− 10	...	− 28
ι Piscium	23 33 46·670	·715	·702	·694	− 45	− 32	− 24
δ Sculptor.	23 42 40·401	...	...	...	...	...	...
ω Piscium	23 53 8·938	·990	·966	...	− 52	− 28	...
2 Ceti	23 57 35·469	...	...	·504	...	...	− 35

The systematic differences among the catalogues are shown by taking the mean of the corrections for each quadrant. They are :—

	(a)	(b)	(c)
	s	s	s
Quadrant I.	− ·034	− ·032	− ·022
„ II.	− ·030	− ·023	− ·025
„ III.	− ·033	− ·027	− ·019
„ IV.	− ·029	− ·019	− ·017
Mean	− ·032	− ·025	− ·021

The near approach to equality among the numbers of the first column shows that the periodic difference between (a) and the results of Greenwich observations between 1840 and 1870 has been eliminated by the system of 12-hour groups. In the case of the Greenwich Six-Year Catalogue for 1840 the difference was

$$+ 0^{s}·014 \cos a - 0^{s}·034 \sin a,$$

and it has continually diminished in the successive catalogues which have since appeared.

Quite remarkable is the large difference of equinoctial point between Greenwich and the other catalogues, which I pointed out in the *Monthly Notices*, vol. xxxv. p. 405, and which has now persisted for about half a century. Its source is probably to be sought not in the absolute declinations of the Sun given by observations, but in the difference between the observed times of transit of the Sun and of the stars. It seems to show an *instrumental* personal equation of a kind not hitherto noticed, and possibly due to differences of thickness of transit threads.

Of the list (a) 101 stars belong to the fundamental catalogue of the American Ephemeris. From each of the corrections (a)

to these stars the constant o^s·037 was subtracted and the mean
of the residuals taken, without regard to sign, with the result—

<div align="center">Mean $r = \pm$ o^s·0145.</div>

This corresponds to—

<div align="center">Probable difference $= \pm$ o^s·012.</div>

Had this determination been extended to all the stars in the list
the probable difference would doubtless be found larger.

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*Comparison of the Greenwich Ten-Year Catalogue with the
 Williamstown Right Ascensions of Polar Stars for 1885. By
 Professor Truman Henry Safford.*

It is pretty sure that the personal equation of an observer
varies in some degree with the apparent velocity of the star.
Hence different observers will, as a rule, assign different right
ascensions to slow-moving stars if they determine them, as is
usual, by comparison with quick-moving ones. The investiga-
tion of this matter can be facilitated by a study of the right
ascensions of high northern stars as given in various catalogues.
While we cannot say that the systematic differences near the
pole are altogether dependent upon personal equation, we can at
least infer that this is partly the case.

The *Greenwich Ten-Year Catalogue* for 1880, just published,
contains 106 stars in common with the *Williamstown Catalogue
of Polar Right Ascensions* for 1885; and the interval of time
between them—on the average no more than three or four years
—enables a comparison to be made without much uncertainty,
due to proper motion.

Such a comparison I have made, employing Professor Auwers's
proper motions as given in the Greenwich Catalogue (except in
isolated cases, where other values are decidedly better), or, lack-
ing these, proper motions determined by Argelander or by myself
from a least-square discussion of all available material.

The primary object of the comparison, together with many
others of the same kind which I have made, has been to obtain
the means of deducing final corrections to be applied in perfect-
ing a least-square discussion, which I have nearly completed, of
170 stars within 10° of the North Pole.

The following are the results of the comparison, in zones of
convenient width. The Williamstown Catalogue contains no
stars south of $+65°$, and only selected stars between $+65°$ and
$+80°$; but between $+80°$ and the pole is nearly complete as far
as the seventh magnitude inclusive :—

Declination.	No. of Stars.	Mean $\Delta a \cos \delta$. W.—G.	Probable Error of 1 Star.	Probable Error of Mean.
		s	s	s
86–90	12	+ 0·0257	± 0·0249	± 0·0063
84–86	10	+ 0·0379	± 0·0203	± 0·0070
82–84	13	+ 0 0266	± 0·0221	± 0·0061
80–82	24	+ 0·0343	± 0·0196	± 0·0045
77–80	13	+ 0·0288	± 0·0215	± 0·0061
74–77	12	+ 0·0158	± 0·0186	± 0·0063
70–74	11	+ 0·0319	± 0·0304	± 0·0066
65–70	11	+ 0·0211	± 0·0218	± 0·0066

The probable errors for one star are derived from the sums of the errors, as compared with the mean of the groups, by the usual formula; their average $\pm 0^{s}\cdot 022$ is taken to calculate the probable errors of the means; and it will be at once seen that these separate means differ among themselves less, on the average, than the probable errors would require; so that there is no reason why we should not accept the general mean—

$$\Delta a \cos \delta = 0^{s}\cdot 0283$$

from all the stars as perfectly representing these separate groups.

In other words, the Greenwich right ascensions of polar stars for 1880 are less than the Williamstown right ascensions for 1885 by $0^{s}\cdot 0283$ sec. δ.

But, on the other hand, when the stars are arranged according to right ascension, we find an apparent slight tendency to periodicity.

I have divided them into seven groups, as follows :—

Limits of R.A. 1880·0.				Mean $\Delta a \cos \delta$.	No. of Stars.	P.E. 1 Star.	P.E. of Mean.
h	m	h	m	s		s	s
0	9–4		2	+ 0·0369	15	± 0·0150	± 0·0052
4	3–7		35	+ 0·0391	15	± 0·0170	± 0·0052
7	36–12		48	+ 0·0264	15	± 0 0264	± 0·0052
13	23–15		39	+ 0·0206	15	± 0·0178	± 0·0052
15	45–18		22	+ 0·0319	15	± 0·0297	± 0·0052
18	35–21		22	+ 0 0049	15	± 0·0178	± 0·0052
21	28–23		54	+ 0·0381	16	± 0 0185	± 0·0051

The separate groups here differ from the general mean $+ c^{s}\cdot 0283$, by quantities of the same order as the probable error of the single means, except in the sixth group, $18^{h} 35^{m}-21^{h} 22^{m}$,

where the discrepancy is rather more than four times its probable error.

The attempt was made, by comparison between Greenwich and Cambridge, 1875 (Professor Rogers's Catalogue of 1213 stars), to come to a more distinct conclusion on this matter; but the only result was to exhibit a somewhat larger and more extended periodicity in the differences for polar stars, so that I must defer further study on this point till I have accumulated a larger stock of materials.

Williams' College Observatory:
      1890 *May* 29.

The Star-Places of the Second Melbourne General Catalogue for 1880.   By A. M. W. Downing, M.A.

For the purpose of discussing the star-places of the Second Melbourne General Catalogue for 1880, they have been compared with those of the Cape Catalogue for the same epoch.   In some cases different values of the proper motions have been adopted in reducing the observations from the mean dates of observation to the common epoch of the two catalogues.   It has, however, been assumed that the effect of the adopted proper motions would not sensibly affect the comparison, when such a large number of stars are available, as is the case in the present instance.   Every star common to the catalogues, and which has been observed in both elements in each, has been used in the comparison.   Only one *erratum* has been detected during the progress of the work—viz. Melbourne No. 43, for N.P.D. $83° 3' 5''·27$ read $83° 4' 5''·27$.

Table I., given below, gives the differences Cape—Melbourne when the stars are arranged in order of N.P.D., and grouped as shown in the table.   The columns " curve " give the readings from curves drawn through the several differences, when laid down as points on cross-ruled paper.   It will be seen that the mean differences in R.A. and N.P.D. are $+0^s·013$ and $+0''·61$ respectively; and that the total number of stars used in the comparison is 881.

Table II. gives the same details as Table I., the stars in this instance, however, being arranged in order of R.A., and the mean differences having been applied, with reversed signs, to the hourly means before their entry in this table.

Tables III. and IV. are formed by reading off from the curves mentioned above the quantities corresponding to the beginning of each hour of R.A., and each 5° of N.P.D.

By the aid of the tables printed on pages 453 and 454 of

vol. xlvii. of the *Monthly Notices,* the comparison is extended so as to include the Cordoba and First Melbourne General Catalogue. In the formation of Tables III. and IV. it must be remarked that the signs of the quantities shown have been arranged so as to give corrections applicable to the star-places of the Cape, Cordoba, and First Melbourne Catalogues, in order to reduce them respectively to the system of the Second Melbourne General Catalogue for 1880.

<div align="center">TABLE I.</div>

N.P.D.	Means.	$\Delta\alpha$ Curve.	Means.	$\Delta\delta$ Curve.	No. of Stars in group.
° °	s	s	"	"	
40–50	−0·016	...	−0·85	...	5
50–60	+ ·013	+0·003	−0·71	−0·59	7
60–65	+ ·001	+ ·005	−0·09	− ·17	17
65–70	+ ·006	+ ·006	+0·22	+ ·25	22
70–75	+ ·008	+ ·005	+0·62	+ ·40	14
75–80	·000	− ·002	+0·12	+ ·24	21
80–85	− ·016	− ·012	+0·07	+ ·13	27
85–90	− ·013	− ·007	+0 25	+ ·27	25
90–95	+ ·014	+ ·003	+0·48	+ ·53	44
95–100	− ·005	+ ·003	+0·89	+ ·80	42
100–105	+ ·006	+ ·009	+0·91	+ ·85	52
105–110	+ ·026	+ ·019	+0·68	+ ·75	44
110–115	+ ·017	+ ·017	+0·72	+ ·67	38
115–120	+ ·004	+ ·008	+0·56	+ ·64	20
120–125	+ ·005	+ ·017	+0·71	+ ·62	90
125–130	+ ·050	+ ·036	+0·48	+ ·62	78
130–135	+ ·036	+ ·039	+0·78	+ ·71	100
135–140	+ ·031	+ ·037	+0·79	+ ·78	73
140–145	+ ·047	+ ·052	+0·75	+ ·79	17
145–150	+ ·081	+ ·068	+0·86	+ ·79	20
150–155	+ ·061	+ ·040	+0·70	+ ·70	14
155–160	− ·044	− ·012	+0·52	+ ·70	15
160–165	− ·019	− ·053	+1·04	+ ·86	8
165–170	− ·127	− ·084	+0·84	+ ·92	17
170–175	− ·063	− ·056	+0·95	+ ·73	41
175–180	+ ·024	...	+0 16	...	30
40–180	+0·013	...	+0·61	...	881

TABLE II.

R.A.	$\Delta\alpha$ Means.	Curve.	$\Delta\delta$ Means.	Curve.	No. of Stars in group.
h h	s	s	"	"	
0–1	+ 0·030	+ 0·020	− 0·06	+ 0·20	51
1–2	− ·004	+ ·014	+ ·40	+ ·20	50
2–3	+ ·031	+ ·010	+ ·06	+ ·07	46
3–4	− ·021	− ·007	− ·25	− ·04	40
4–5	− ·015	− ·017	+ ·30	+ ·16	38
5–6	− ·014	− ·013	+ ·25	+ ·21	49
6–7	− ·008	− ·014	+ ·03	+ ·07	40
7–8	− ·026	− ·015	− ·05	+ ·04	40
8–9	+ ·003	− ·002	+ ·22	+ ·08	49
9–10	+ ·012	+ ·015	− ·08	− ·02	41
10–11	+ ·030	+ ·033	− ·14	− ·13	41
11–12	+ ·058	+ ·047	− ·16	− ·22	36
12–13	+ ·039	+ ·035	− ·42	− ·33	32
13–14	+ ·001	+ ·032	− ·31	− ·39	25
14–15	+ ·084	+ ·036	− ·49	− ·43	24
15–16	− ·028	+ ·015	− ·48	− ·39	22
16–17	+ ·030	+ ·005	− ·17	− ·35	25
17–18	− ·012	− ·006	− ·55	− ·35	27
18–19	− ·029	− ·015	− ·10	− ·30	31
19–20	+ ·014	− ·005	− ·41	− ·25	26
20–21	− ·016	− ·025	− ·07	− ·24	27
21–22	− ·081	− ·042	− ·39	− ·16	34
22–23	+ ·013	− ·008	+ ·24	+ ·15	38
23–24	+ ·023	+ ·023	+ ·50	+ ·30	49

TABLE III.

R.A.	Cape, 1880.		Cordoba, 1875.		Melbourne, 1870.	
h	s	"	s	"	s	"
0·0	− 0·021	− 0·25	+ 0·003	− 0·06	+ 0·012	− 0·02
1·0	·017	·20	·010	·06	+ ·011	− ·08
2·0	·011	·14	·005	− ·04	− ·015	·00
3·0	− ·003	·01	·007	+ ·01	·046	+ ·22
4·0	+ ·013	·04	·033	− ·11	·032	·23
5·0	·016	·20	·026	·27	− ·001	+ ·03
6·0	·014	·15	+ ·001	·27	+ ·008	− ·09
7·0	·016	·04	− ·016	·19	− ·008	·09
8·0	+ ·010	·05	·020	·16	·036	− ·04
9·0	− ·007	− ·03	·021	− ·07	·054	+ ·06
10·0	·024	+ ·08	·018	+ ·07	·059	− ·02
11·0	·042	·18	·038	·12	·057	·14

R.A.	Cape, 1880.		Cordoba, 1875.		Melbourne, 1870.	
h	s	″	s	″	s	″
12·0	−0·041	+0·28	−0·074	+0·22	−0·038	−0·12
13·0	·032	·36	·072	·33	·015	− ·06
14·0	·032	·42	·057	·35	− ·009	+ ·16
15·0	·024	·43	·033	·29	+ ·012	·28
16·0	− ·010	·37	− ·011	·23	·032	·24
17·0	·000	·35	+ ·006	·26	·029	·27
18 0	+ ·012	·32	·023	·36	·022	·26
19·0	·010	·27	·023	·39	·010	·28
20·0	·015	·25	·034	·39	·017	·35
21·0	·033	·21	·058	·44	·052	·37
22·0	+ ·028	+ ·03	·053	·30	·060	·23
23·0	− ·010	− ·23	+ ·010	+ ·02	+ ·021	+ ·02

TABLE IV.

N.P.D.	Cape, 1880.		Cordoba, 1875.		Melbourne, 1870.	
°	s	″	s	″	s	″
55	−0·003	+0·59	...	...	−0·010	−0·31
60	·004	+ ·33	...	...	·006	·32
65	·005	− ·02	...	...	·002	·33
70	·005	·35	...	...	− ·001	·34
75	− ·002	·31	...	...	+ ·011	·09
80	+ ·008	·17	...	...	·025	·25
85	·011	·18	...	...	·020	·41
90	+ ·002	·39	...	...	+ ·002	·49
95	− ·004	·67	−0·032	+0·05	− ·009	·52
100	·006	·85	·038	− ·14	·020	·50
105	·013	·80	·051	·10	·038	·31
110	·019	·70	·060	·33	·056	·26
115	·011	·65	·059	·46	·049	·35
120	·010	·63	·074	·31	·046	·44
125	·026	·63	·091	·31	·051	·48
130	·038	·67	·098	·47	·052	·37
135	·038	·76	·116	·44	·064	·26
140	·044	·78	·132	·28	·077	·26
145	·060	·79	·108	·26	·073	·25
150	·053	·75	·063	·28	·058	− ·11
155	− ·015	·70	− ·044	·28	·039	+ ·03
160	+ ·032	·77	·000	·33	·037	·07
165	·070	·90	+ ·077	·10	− ·013	+ ·03
170	·070	·87	·128	·04	+ ·003	− ·04
175	+ ·041	− ·70	+ ·154	− ·23	− ·022	− ·10

Corrections to the Elements of the Orbit of Juno.
By A. M. W. Downing, M.A.

My attention having been drawn to the large and increasing errors of the computed places of *Juno*, as given in the *Nautical Almanac* (amounting to some 3′ in geocentric longitude in 1887), I have endeavoured in the present paper to deduce corrections to the assumed elements of the orbit, so as to obtain elements which shall represent the observed places of the planet with sufficient accuracy for, I hope, some years to come.

The observations of *Juno* which are discussed in this paper are those published in the volumes of *Greenwich Observations* from 1864 to 1887 inclusive. The discussion therefore embraces observations made at the Paris Observatory during the years 1864 to 1878, as well as those made at Greenwich during the whole period. Le Verrier's Tables of the Sun were first used in the *Nautical Almanac* for the year 1864, and it has been assumed that the tabular places of the Sun are sensibly accurate throughout the years with which we are here concerned.

The first step in the discussion of the observations, both Greenwich and Paris, is to reduce them to a uniform system. That adopted for the R.A.'s is the standard system of R.A.'s deduced from 12-hour groups of clock-stars for 1872·0, printed on pp. 21 and 22 of the Introduction to the *Greenwich Nine-Year Catalogue*, and which has been used in the reduction of the Greenwich observations for 1878 to 1888 inclusive. For the years 1864 to 1869 the Greenwich R.A.'s depend on those of the First Seven-Year Catalogue, whilst for the years 1872 to 1877 they depend on those of the Second Seven-Year Catalogue. The following table (deduced from the comparisons printed on page 8 of the above-mentioned Introduction) gives the corrections applicable to the R.A.'s observed at Greenwich during the specified periods to reduce them to the adopted system :—

R.A.	1864—1869.	1870—1877.
h h	s	s
0–3	+0·02	+0·02
3–6	− ·01	+ ·01
6–9	− ·02	·00
9–12	− ·01	+ ·01
12–15	·00	+ ·01
15–18	·00	+ ·01
18–21	+ ·02	+ ·03
21–24	+ ·03	+ ·03

Observations made since 1878·0 require no correction.

In the reduction of the Paris observations of R.A. a "provisional" standard catalogue (constructed in 1854) was used

during the period 1864–1871, with different corrections each year, deduced from then recent observations; whilst during the period 1872–1878 the corrections to the provisional catalogue were deduced from observations extending over the years 1856–1869. It was found, however, that the corrections given in the following table would reduce the Paris observations made throughout the whole period 1864–1878 to the adopted system with sensible accuracy :—

R.A.	Corr. to Paris.	R.A.	Corr. to Paris.
h h	s	h h	s
0–3	+ 0·02	12–15	+ 0·01
3–6	− ·01	15–18	+ ·02
6–9	− ·01	18–21	+ ·03
9–12	·00	21–24	+ ·03

With regard to the N.P.D.'s observed at Greenwich during the years 1864–1882, it is necessary to correct them for the law for R.–D.—viz. $a + b' \sin z \cos^2 z$, assumed during those years, so as to make them depend on the law $a + b \sin z$. This has been done by assuming that the mean Z.D. at which reflection observations were made during those years (and from which, therefore, the values of a and b' were deduced) was 25°, and that therefore $b = ·8 \times b'$. It is also necessary to correct observations made during 1864–1876 by the quantities given in the table on p. 27 of the Addendum to the Introduction to the *Nine-Year Catalogue*, to reduce them to the refractions of Bessel's Tabulæ, and to colatitude 38° 31′ 21″·90. It is further necessary to correct observations made during 1868–1874, for errors due to wear in the micrometer-screws of the transit-circle, by the quantities given on p. 14 of the Introduction to the *Nine-Year Catalogue*. The following table gives the corrections to the observed N.P.D.'s corresponding to the N.P.D. of *Juno*, at the time of opposition, in the different years (exclusive of the correction for wear of screws, which was applied to each individual observation) :—

Year.	N.P.D.	Corr.	Year.	N.P.D.	Corr.
	°	″		°	″
1864	94	− 0·3	1874	94	+ 1·2
1865	94	− 0·7	1876	87	+ 1·0
1867	86	+ 0·3	1877	94	+ 0·7
1868	92	+ 1·3	1878	94	+ 0·6
1869	95	+ 1·2	1880	86	+ 0·3
1871	87	+ 1·0	1881	92	+ 0·1
1872	90	+ 1·1	1882	95	+ 0·2
1873	95	+ 1·3			

Observations made since 1883·0 require no correction.

The Paris observations in N.P.D. depend on the assumed places of standard stars taken from the corrected "provisional" catalogue referred to above. From a discussion of the places of stars in this catalogue, situated between N.P.D. 70° and 110°, it was found that the following corrections were applicable to Paris observations, between these limits of N.P.D., made during the period 1864–1878, to reduce them to the adopted system of N.P.D.'s:—

R.A.	Corr. to Paris.	R.A.	Corr. to Paris.
h h	''	h h	''
0–3	+0''·4	12–15	+0''·4
3–6	+0·3	15–18	+0·6
6–9	+0·2	18–21	+0·7
9–12	+0·2	21–24	+0·5

The publication of Paris observations of minor planets in the volumes of *Greenwich Observations* was intermitted after 1879; and there are no Paris observations of *Juno* printed in the Greenwich volumes after 1878.

The requisite corrections, deduced from those given in the foregoing tables, have been applied to the quantities given in the section "Errors of the Tabular Heliocentric Places of the Planets," printed in successive volumes of *Greenwich Observations*. The corrected equations connecting the error of tabular heliocentric longitude (δl), the error of tabular heliocentric ecliptic north polar distance (δb), and the error of projected radius vector of *Juno* ($\delta \rho$) are given below, together with the mean dates of the groups from which the normal places have been formed, and the number of observations in each group.

No.	Mean Date.	Equations.		No. of Obs.
1	1864 June 10	$- 8''\cdot44 = + 1\cdot4628\delta l'' + 3102''\delta\rho,$	$\delta b'' = + 0''\cdot04 - 6546''\delta\rho$	5
2	25	$- 8\cdot75 = + 1\cdot418 + 11728$	$= - 0\cdot40 - 6294$	5
3	July 6	$- 6\cdot84 = + 1\cdot360 + 16835$	$= - 0\cdot16 - 5862$	2
4	1865 Sept. 2	$- 27\cdot31 = + 1\cdot769 - 9819$	$= - 3\cdot98 - 1756$	4
5	13	$- 27\cdot10 = + 1\cdot788 + 6490$	$= - 4\cdot75 - 892$	8
6	27	$- 25\cdot83 = + 1\cdot729 + 27421$	$= - 4\cdot35 + 335$	8
7	1867 Mar. 1	$- 22\cdot47 = + 1\cdot574 - 3316$	$= + 4\cdot71 + 1354$	5
8	27	$- 22\cdot57 = + 1\cdot477 + 18293$	$= + 3\cdot70 + 375$	5
9	1868 May 7	$- 16\cdot89 = + 1\cdot436 - 3383$	$= + 1\cdot93 - 5377$	1
10	17	$- 15\cdot70 = + 1\cdot441 + 2288$	$= + 1\cdot97 - 5480$	4
11	25	$- 16\cdot56 = + 1\cdot426 + 6730$	$= + 1\cdot21 - 5442$	4
12	June 6	$- 16\cdot32 = + 1\cdot379 + 12640$	$= + 1\ 36 - 5186$	4
13	1869 July 17	$- 31\cdot16 = + 1\cdot573 - 8243$	$= - 3\ 66 - 7444$	4
14	29	$- 31\cdot73 = + 1\cdot594 + 4905$	$= - 3\cdot18 - 7439$	4
15	Aug. 5	$- 30\cdot45 = + 1\cdot583 + 9421$	$= - 3\cdot53 - 7283$	3

No.	Mean Date.	Equations.		No. of Obs.
16	1869 Aug. 13	$- 29''\!\cdot\!49 = + 1\cdot549\,\delta l'' + 16597''\delta\rho,\ \delta b'' =$	$- 4''\!\cdot\!49 - 6974''\delta\rho$	3
17	1871 Jan. 26	$- 59\cdot94 = + 1\cdot787 + 9813$	$= + 7\cdot89 + 12476$	1
18	Feb. 13	$- 60\cdot16 = + 1\cdot633 + 32398$	$= + 9\cdot47 + 10027$	1
19	1872 Apr. 19	$- 26\cdot53 = + 1\cdot450 - 1293$	$= + 3\cdot32 - 4220$	3
20	May 4	$- 27\cdot55 = + 1\cdot426 + 7937$	$= + 4\cdot18 - 4272$	5
21	1873 June 23	$- 35\cdot61 = + 1\cdot500 - 1686$	$= - 1\cdot49 - 7297$	5
22	July 17	$- 32\cdot43 = + 1\cdot446 + 14526$	$= - 0\cdot94 - 6938$	4
23	1874 Nov. 12	$- 132\cdot25 = + 2\cdot004 + 17358$	$= - 10\cdot79 + 19646$	5
24	1876 Mar. 30	$- 43\cdot45 = + 1\cdot492 + 2164$	$= + 7\cdot65 - 2284$	6
25	Apr. 19	$- 41\cdot45 = + 1\cdot420 + 14570$	$= + 7\cdot67 - 2445$	5
26	1877 June 4	$- 41\cdot02 = + 1\cdot457 + 2059$	$= + 1\cdot15 - 6338$	4
27	22	$- 38\cdot80 = + 1\cdot406 + 12450$	$= + 0\cdot88 - 6049$	4
28	1878 Aug. 23	$- 93\cdot16 = + 1\cdot722 - 7613$	$= - 11\cdot79 - 4033$	2
29	Sept. 5	$- 94\cdot60 = + 1\cdot729 + 9874$	$= - 13\cdot78 - 3296$	4
30	21	$- 90\cdot04 = + 1\cdot637 + 29940$	$= - 13\cdot69 - 2138$	7
31	1880 Feb. 18	$- 72\cdot86 = + 1\cdot609 - 6716$	$= + 11\cdot69 + 3200$	1
32	Mar. 19	$- 71\cdot42 = + 1\cdot496 + 21244$	$= + 12\cdot49 + 1676$	6
33	1881 May 12	$- 45\cdot20 = + 1\cdot443 + 2110$	$= + 4\cdot46 - 5276$	4
34	June 1	$- 45\cdot64 = + 1\cdot382 + 12562$	$= + 4\cdot77 - 5011$	4
35	1882 July 18	$- 71\cdot79 = + 1\cdot567 - 368$	$= - 5\cdot53 - 7546$	3
36	Aug. 13	$- 69\cdot50 = + 1\cdot481 + 20906$	$= - 7\cdot46 - 6794$	5
37	Sept. 18	$- 55\cdot07 = + 1\cdot188 + 33701$	$= - 10\cdot19 - 4053$	5
38	1884 Jan. 11	$- 162\cdot40 = + 1\cdot868 + 12076$	$= + 11\cdot98 + 17185$	1
39	Feb. 17	$- 123\cdot40 = + 1\cdot448 + 49724$	$= + 14\cdot08 + 10654$	9
40	Mar. 14	$- 97\cdot10 = + 1\cdot169 + 48987$	$= + 14\cdot18 + 5971$	2
41	1885 Mar. 30	$- 57\cdot77 = + 1\cdot426 - 9646$	$= + 10\cdot97 - 3541$	1
42	Apr. 20	$- 56\cdot92 = + 1\cdot457 + 2821$	$= + 8\cdot18 - 3959$	1
43	May 2	$- 56\cdot92 = + 1\cdot424 + 9740$	$= + 9\cdot03 - 3944$	1
44	19	$- 51\cdot90 = + 1\cdot332 + 17066$	$= + 7\cdot82 - 3628$	2
45	1886 June 11	$- 63\cdot79 = + 1\cdot476 - 5791$	$= - 0\cdot90 - 6972$	2
46	July 1	$- 63\cdot44 = + 1\cdot474 + 7829$	$= - 1\cdot39 - 7016$	5
47	14	$- 63\cdot69 = + 1\cdot418 + 15516$	$= - 2\cdot38 - 6617$	3
48	1887 Oct. 14	$- 214\cdot36 = + 1\cdot958 - 3690$	$= - 23\cdot42 + 11468$	5
49	22	$- 213\cdot82 = + 1\cdot954 + 13584$	$= - 23\cdot48 + 12421$	5
50	31	$- 210\cdot09 = + 1\cdot901 + 31203$	$= - 23\cdot44 + 13446$	2
51	Nov. 16	$- 191\cdot41 = + 1\cdot714 + 56008$	$= - 21\cdot07 + 14225$	2
52	28	$- 173\cdot55 = + 1\cdot542 + 66540$	$= - 19\cdot74 + 14028$	3
53	Dec. 7	$- 159\cdot18 = + 1\cdot420 + 69854$	$= - 18\cdot43 + 13511$	2
54	19	$- 147\cdot48 = + 1\cdot266 + 71960$	$= - 16\cdot40 + 12388$	2

The next step is to eliminate $\delta\rho$ between the two equations corresponding to each normal date; so that we have a single equation of the form

$$a\,\delta l + \beta\,\delta b + \gamma = 0,$$

corresponding to each normal date.

To express the variations of heliocentric longitude and heliocentric ecliptic north polar distance in terms of the variations of the elements of orbit, the following formulæ have been used :—

$$\delta l = \frac{\cos i\,a^2}{\cos^2 B\,R^2}\cos\phi\{(t-t_0)\delta n + \delta\epsilon\}$$

$$+\frac{\cos i}{\cos^2 B}\left(1-\frac{a^2}{R^2}\cos\phi\right)\delta\pi$$

$$+\left(1-\frac{\cos i}{\cos^2 B}\right)\delta\Omega$$

$$-\tan B\cos(l-\Omega)\,\delta i$$

$$+\frac{\cos i}{\cos^2 B}\left(\frac{2}{\cos\phi}+\tan\phi\cos v\right)\sin v\,\delta\phi,$$

$$-\delta b = \sin i\cos(l-\Omega)\frac{a^2}{R^2}\cos\phi\{(t-t_0)\delta n+\delta\epsilon\}$$

$$+\sin i\cos\left(l-\Omega\right)\left(1-\frac{a^2}{R^2}\cos\phi\right)\delta\pi$$

$$-\sin i\cos(l-\Omega)\,\delta\Omega$$

$$+\sin(l-\Omega)\,\delta i$$

$$+\sin i\cos(l-\Omega)\left\{\frac{2}{\cos\phi}+\tan\phi\cos v\right\}\sin v\,\delta\phi.$$

where

l is the heliocentric longitude,

B „ „ latitude,

b „ „ ecliptic north polar distance,

a „ semi-axis major of orbit,

R „ radius vector of planet,

v „ true anomaly of planet,

$t-t_0$ „ time in days from 1876, March 19ᵈ·0

and

$n, \epsilon, \pi, \Omega, i$ and s ($=\sin\phi$) are the elements of the orbit.

The required quantities have been taken from, or have been computed from quantities taken from, the *Nautical Almanacs* of the different years.

By the substitution of the values of δl and δb thus obtained in the equations of the form $a\delta l + \beta\delta b + \gamma = 0$, the following equations of condition (where $\delta N = 1000\,\delta n$) connecting the errors of the six elements, have been formed. The adopted weight is simply the number of observations on which each equation depends.

These equations of condition have been solved by the method of least squares, and the subjoined normal equations formed; the values of the six unknown quantities derived from which have been substituted in the equations of condition, and the residuals (given in the last column) computed.

It is to be observed that in the equations of condition the coefficients are logarithms, whilst in the normal equations the coefficients are natural numbers.

Equations of Condition.

No.								Weights.	Residuals.
1	−0·61839N	+9·984988e	+9·733208π	−8·6532186	+9·6454281	−9·9965186	+ $8''·46=0$	5	+ 0·64
2	−0·61209	+9·98000	+9·71630	−8·76343	+0·25600	−0·02857	+ 8·00=0	5	+ 0·56
3	−0·59415	+9·96332	+9·69108	−8·69897	+0·45697	−9·07188	+ 6·38=0	2	− 0·17
4	−1·17541	+0·58984	+9·95999	−0·08243	−9·74974	−0·76864	+ 49·57=0	4	+ 1·61
5	−9·73277	+9·14922	−8·55630	+0·22608	+9·60853	−8·86923	− 7·46=0	8	− 2·10
6	−2·02732	+1·44458	−0·88694	−1·26475	+0·22246	−1·53396	+381·90=0	8	− 0·53
7	−0·86576	+0·28646	+9·10037	−9·68753	−9·84323	+0·61857	+ 34·00=0	5	+ 4·69
8	+1·43502	−0·91913	−9·99782	+1·03238	+1·02094	−1·26002	−157·92=0	5	+ 7·02
9	−0·39699	+9·92840	+9·73159	+8·67210	−9·84011	+8·97772	+ 15·68=0	1	+ 1·01
10	−0·42049	+9·96332	+9·76864	−8·81291	+9·37107	+8·57978	+ 16·52=0	4	− 0·30
11	−0·43782	+9·98227	+9·78675	−9·16435	−9·99078	−8·17609	+ 18·06=0	4	+ 0·34
12	−0·45215	+9·99826	+9·80277	−9·40140	+0·32160	−9·00000	+ 19·63=0	4	+ 1·13
13	−0·57634	+0·18949	+9·29003	−9·22789	−9·81823	−0·49415	+ 35·21=0	4	+ 1·06
14	−0·51746	+0·13258	+9·13988	+8·85733	+9·82217	−0·43791	+ 29·63=0	4	+ 0·89
15	−0·48684	+0·10346	+9·04139	+9·30963	+0·04218	−0·40824	+ 25·88=0	3	− 0·64
16	−0·41682	+0·03503	+8·88081	+9·59106	+0·26007	−0·33905	+ 18·80=0	3	− 2·48
17	−0·62991	+0·35603	−9·77232	+9·03743	+9·99200	+0·52673	+ 53·73=0	1	− 0·63
18	−0·42588	+0·15594	−9·51720	+9·77428	+0·38274	+0·35353	+ 29·56=0	1	− 2·37

No.	$-0.107818N$	$+9.95231\,8a$	$+9.69461\,8\pi$	$+8.77085\,8\Omega$	$-9.561108i$	$+9.99870\,8\varphi$		Weights.	Residuals.
19	$-0.107818N$	$+9.95231\,8a$	$+9.694618\pi$	$+8.7708585\Omega$	-9.5611081	$+9.998708\varphi$	$+\ \ 25.51 = 0$	3	$+\ \ 0.52$
20	-0.19398	$+0.04336$	$+9.79727$	-9.48430	$+0.03902$	$+0.04610$	$+\ \ 35.32 = 0$	5	$+\ \ 3.36$
21	-0.03908	$+0.03902$	$+9.65610$	-8.67210	-9.17319	-0.25575	$+\ \ 35.95 = 0$	5	$+\ \ 0.89$
22	-9.97839	$+9.98900$	$+9.56110$	$+9.02531$	$+0.32139$	-0.23019	$+\ \ 30.46 = 0$	4	$+\ \ 0.42$
23	-0.26441	$+0.57148$	-0.20167	-9.12710	$+9.69984$	-9.87795	$+141.78 = 0$	5	$+12.45$
24	$+8\ 13799$	$+0.09656$	$+9.61909$	-9.23553	$+9.25763$	$+0.35736$	$+\ \ 50.70 = 0$	6	$+\ \ 2.62$
25	$+8.77875$	$+0.28735$	$+9.85370$	-0.09026	$+0.29292$	$+0.53161$	$+\ \ 87.16 = 0$	5	$+\ \ 8.91$
26	$+9.62226$	$+9.97681$	$+9.74663$	-8.68124	$+9.41996$	-9.88252	$+\ \ 41.39 = 0$	4	$+\ \ 1.49$
27	$+9.64175$	$+9.97909$	$+9.73799$	-8.97313	$+0.30146$	-9.94399	$+\ \ 40.61 = 0$	4	$+\ \ 0.75$
28	$+0.37027$	$+0.39533$	-9.59329	-9.56937	-9.62941	-0.63949	$+115.42 = 0$	2	$+\ \ 0.80$
29	$+0.05664$	$+0.10209$	$\cdot9.36922$	$+9.84386$	$+9.87967$	-0.33082	$+\ \ 53.32 = 0$	4	$-\ \ 0.72$
30	-0.24977	-0.28780	$+9.62014$	$+0.49969$	$+0.32899$	$+0.49541$	$-101.67 = 0$	7	$-\ \ 0.54$
31	$+0.46994$	$+0.31429$	-8.68124	-9.60853	-9.69020	$+0.60670$	$+\ \ 97.39 = 0$	1	$-\ \ 3.28$
32	-0.27996	-0.11528	-8.70757	$+0.45500$	$+0.34537$	-0.41714	$-\ \ 86.90 = 0$	6	-11.85
33	$+0.24210$	$+9.96802$	$+9.76268$	-8.80618	$+9.28103$	$+9.44404$	$+\ \ 46.98 = 0$	4	$-\ \ 1.50$
34	$+0.29128$	$+0.01242$	$+9.81023$	-9.46687	$+0.31345$	$+9.34439$	$+\ \ 57.60 = 0$	4	$+\ \ 3.47$
35	$+0.49951$	$+0.12646$	$+9.39620$	-8.30103	$+9.12057$	-0.42243	$+\ \ 72.06 = 0$	3	$-\ \ 2.25$
36	$+0.32917$	$+9.95999$	$+9.08636$	$+9.65031$	$+0.39777$	-0.26031	$\ \ 46.53 = 0$	5	$-\ \ 1.59\cdot$

No.	$-9\cdot67480N$	$-9\cdot303208\varepsilon$	$-8\cdot079188\pi$	$+0\cdot146138\Omega$	$+0\cdot75404\delta\iota$	$+9\cdot6053186\phi$		Weights	Residuals
37	$-9\cdot67480$	$-9\cdot303208$	$-8\cdot079188$	$+0\cdot146138$	$+0\cdot75404$	$+9\cdot6053186$	$-29\cdot66=0$	5	$-10\cdot82$
38	$+0\cdot89340$	$+0\cdot43791$	$-9\cdot95952$	$+8\cdot57978$	$+9\cdot90417$	$+0\cdot49762$	$+153\cdot98=0$	1	$+6\cdot36$
39	$+0\cdot51212$	$+0\cdot05115$	$-9\cdot49554$	$+9\cdot80346$	$+0\cdot58501$	$+0\cdot19700$	$+57\cdot69=0$	9	$-4\cdot15$
40	$-9\cdot77789$	$-9\cdot31387$	$+8\cdot68124$	$+0\cdot12287$	$+0\cdot76738$	$-9\cdot50379$	$-19\cdot24=0$	2	$+0\cdot19$
41	$+0\cdot29959$	$+9\cdot78104$	$+9\cdot46389$	$+9\cdot72509$	$-0\cdot21245$	$+9\cdot93095$	$+27\cdot89=0$	1	$-7\cdot85$
42	$+0\cdot53986$	$+0\cdot01870$	$+9\cdot72591$	$-9\cdot07555$	$+9\cdot41330$	$+0\cdot13226$	$+62\cdot75=0$	1	$-2\cdot32$
43	$+0\cdot60823$	$+0\cdot08565$	$+9\cdot80414$	$-9\cdot63448$	$+0\cdot13194$	$+0\cdot17551$	$+79\cdot22=0$	1	$+2\cdot39$
44	$+0\cdot66629$	$+0\cdot14145$	$+9\cdot87506$	$-9\cdot90472$	$+0\cdot46135$	$+0\cdot19479$	$+88\cdot68=0$	2	$+3\cdot21$
45	$+0\cdot58906$	$+0\cdot01662$	$+9\cdot69548$	$-8\cdot77085$	$-9\cdot89597$	$-0\cdot17085$	$+64\cdot54=0$	2	$-4\cdot25$
46	$+0\cdot58053$	$+0\cdot00604$	$+9\cdot65801$	$+7\cdot69897$	$+0\cdot06296$	$-0\cdot18977$	$+61\cdot89=0$	5	$-4\cdot45$
47	$+0\cdot55443$	$+9\cdot97359$	$+9\cdot60746$	$+8\cdot86923$	$+0\cdot37310$	$-0\cdot17435$	$+58\cdot11=0$	3	$-3\cdot11$
48	$+1\cdot11212$	$+0\cdot48615$	$-0\cdot07591$	$+8\cdot92942$	$-9\cdot56348$	$-0\cdot36642$	$+206\cdot82=0$	5	$-3\cdot01$
49	$+1\cdot17566$	$+0\cdot54888$	$-0\cdot14613$	$-9\cdot26951$	$+0\cdot60531$	$-0\cdot38881$	$+239\cdot50=0$	5	$-3\cdot90$
50	$+1\cdot21383$	$+0\cdot58614$	$-0\cdot19089$	$-9\cdot66638$	$+0\cdot07882$	$-0\cdot37401$	$+264\cdot49=0$	2	$-1\cdot41$
51	$+1\cdot23252$	$+0\cdot60325$	$-0\cdot21880$	$-9\cdot80754$	$+0\cdot40037$	$-0\cdot27784$	$+274\cdot37=0$	2	$-4\cdot62$
52	$+1\cdot22025$	$+0\cdot58973$	$-0\cdot21165$	$-9\cdot85612$	$+0\cdot52595$	$-0\cdot15229$	$+267\cdot18=0$	3	$-1\cdot84$
53	$+1\cdot20238$	$+0\cdot57089$	$-0\cdot19645$	$-9\cdot86451$	$+0\cdot59073$	$-0\cdot02449$	$+254\cdot47=0$	2	$-3\cdot25$
54	$+1\cdot17507$	$+0\cdot54245$	$-0\cdot17114$	$-9\cdot86747$	$+0\cdot67265$	$-9\cdot78319$	$+242\cdot74=0$	2	$+1\cdot46$

Normal Equations.

$+102049 \cdot 9218\delta N$	$-23867 \cdot 784\delta e$	$+5939 \cdot 1918\delta\pi$	$+17008 \cdot 2438\delta\Omega$	$+900 \cdot 1118\delta i$	$+26541 \cdot 2708\delta\phi$	$-25636 \cdot 626 = 0$
$-23867 \cdot 784$	$+7213 \cdot 550$	$-1803 \cdot 145$	$-4680 \cdot 678$	$+237 \cdot 062$	$-7161 \cdot 586$	$+12536 \cdot 019 = 0$
$+5939 \cdot 191$	$-1803 \cdot 145$	$+576 \cdot 320$	$+1097 \cdot 233$	$-194 \cdot 644$	$+2298 \cdot 542$	$-31261 \cdot 762 = 0$
$+17008 \cdot 243$	$-4680 \cdot 678$	$+1097 \cdot 233$	$+3475 \cdot 270$	$+440 \cdot 675$	$+4103 \cdot 138$	$-72149 \cdot 789 = 0$
$+900 \cdot 111$	$+237 \cdot 062$	$-194 \cdot 644$	$+440 \cdot 675$	$+1492 \cdot 595$	$-1421 \cdot 714$	$+13545 \cdot 549 = 0$
$+26541 \cdot 270$	$-7161 \cdot 586$	$+2298 \cdot 542$	$+4103 \cdot 138$	$-1421 \cdot 714$	$+11956 \cdot 020$	$-102418 \cdot 880 = 0$

Whence

$$\delta N = -7 \cdot 160 \text{ with weight } 13392 \cdot 2$$
$$\delta e = -38 \cdot 289 \text{ ,, ,, } 315 \cdot 3$$
$$\delta \pi = -0 \cdot 522 \text{ ,, ,, } 66 \cdot 5$$

$$\delta \Omega = +4 \cdot 010 \text{ with weight } 156 \cdot 2$$
$$\delta i = +0 \cdot 351 \text{ ,, ,, } 627 \cdot$$
$$\delta \phi = +0 \cdot 293 \text{ ,, ,, } 1669 \cdot 1$$

The corrections to the assumed elements of *Juno* are therefore:—

$$dn = +0 \cdot 00716$$
$$de = +38 \cdot 29 + dn \times t$$
$$d\pi = +0 \cdot 52$$

$$d\Omega = -4 \cdot 01$$
$$di = -0 \cdot 35$$
$$d\phi = -0 \cdot 29$$

where t is the number of days from 1876 March $19^{d} \cdot 0$ G.M.T.

From these corrections to the assumed elements of *Juno*, places near the time of each opposition have been computed for the transit at Greenwich, and from the observed errors of the uncorrected ephemerides (as given in the *Nautical Almanack* of the different years) the following errors of R.A. and N.P.D. (given in the columns headed " Corrected ") have been formed, by comparing the observed and computed places, thus showing the errors of places computed from the corrected elements :—

Date.	$\delta a.$ Uncorrected.	Corrected.	$\delta a \cos \delta.$ Corrected.	δ N.P.D. Uncorrected.	Corrected.
1864 June 8	− 0·53	−0·04	− 0·6	− 1·2	−0·2
1865 Sept. 13	− 1·88	−0·12	− 1·8	+ 2·4	−0·5
1867 Mar. 1	− 1·58	−0·21	− 3·2	− 1·8	+0·1
1868 May 18	− 1·03	−0·02	− 0·3	− 0·9	+0·9
1869 July 30	− 2·06	−0·04	− 0·6	+ 2·0	+0·4
1871 Jan. 27	− 4·01	−0·18	− 2·7	+ 0·9	+1·7
1872 April 21	− 1·75	−0·03	− 0·5	− 4·4	−0·3
1873 June 21	− 2·26	−0·05	− 0·8	− 1·1	−0·4
1874 Nov. 13	− 8·33	−0·70	−10·5	+ 15·1	−0·3
1876 Mar. 31	− 2·97	−0·18	− 2·7	− 6·6	+0·8
1877 June 6	− 2·60	−0·11	− 1·7	− 3·6	−0·2
1878 Aug. 24	− 6·25	−0·13	− 2·0	+ 14·5	+0·8
1880 Feb. 21	− 4·98	+0·17	+ 2·6	− 8·9	+0·4
1881 May 10	− 2·91	+0·09	+ 1·4	− 5·5	+1·1
1882 July 16	− 4·63	+0·13	+ 2·0	+ 3·9	−0·3
1884 Jan. 13	−10·15	+0·22	+ 3·3	+ 3·5	+0·9
1885 April 19	− 3·76	+0·25	+ 3·8	− 8·9	+2·0
1886 June 13	− 4·04	+0·27	+ 4·1	− 2·2	−0·2
1887 Oct. 12	−14·02	+0·15	+ 2·3	+ 36·5	−0·9

The assumed elements of *Juno*, from which the *Nautical Almanac* ephemerides during the years mentioned above have been computed, were deduced by Mr. Hind from observations made near the times of twelve oppositions from 1841–55. The discussion is published in the *Nautical Almanac* for 1859.

An inspection of the errors exhibited in the above table will show that the corrected elements give a very good representation of the observed places during the years 1864–1887, with the exception of those observed in the year 1874, which give a dis-cordant result in R.A.* It will be remarked that the signs of the

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* The observed place in this case depends on 5 accordant observations, and leads one to suspect an error—possibly in the application of the perturbations— in the ephemeris. I have made inquiries on this point, but am informed that no such error can be detected. I have not, therefore, felt justified in rejecting this normal place.

errors of R.A. are negative in the earlier years, and positive in the later years, as if the mean motion required still further correction.   It must be pointed out, however, that the comparison between the observed and computed places has not been made with any attempt at great accuracy, but rather as a general check on the correctness of the work ; and that, in particular, the perturbations have not been recomputed as, of course, they ought to have been had the intention been to deduce a *definitive* orbit of the planet.   To that the present paper makes no pretension, the object being merely to deduce corrections to the assumed elements of the orbit so as to obtain elements sufficiently accurate for the purpose of computing ephemerides for some years to come. And, as far as can be seen, that object has been attained.

My thanks are due to the Council of the Royal Society for a grant to defray the expenses of the computations, the results of which are embodied in this paper.

Blackheath :
   1890 *June* 4.

On Star-Correction Tables.   By W. H. Finlay, M.A.

The computation of star-corrections forms no small part of the reductions for the formation of a catalogue, as every astronomer who has taken part in such work knows well; so that any attempt to shorten the time required for these computations, without sacrificing accuracy or simplicity, is worthy of consideration.   I think that this may be satisfactorily done to a considerable extent by tables in the following way.   We have for any star—

$$a' - a = f + g \sin (G + a) \tan \delta + h \sin (H + a) \sec \delta,$$

$$\delta' - \delta = \iota \cos \delta + g \cos (G + a) + h \cos (H + a) \sin \delta.$$

Now I put—

$$P = \tfrac{1}{15} \cdot g_0 \sin (G + a) \tan \delta, \qquad P' = g_0 \cos (G + a),$$

$$Q = \tfrac{1}{15} \cdot h_0 \sin (H + a) \sec \delta, \qquad Q' = h_0 \cos (H + a) \sin \delta,$$

and

$$I = \iota \cos \delta,$$

where g_0 and h_0 are arbitrarily chosen constants ; and I tabulate the values of P, Q, Q' for each degree of declination and for every two minutes of time.   The value of P', which is independent of the declination, is given in a separate table for every minute (or smaller interval if desired) of time.

The star-corrections for any given date are then—

$$a' - a = \tfrac{1}{15}.f + P.\frac{g}{g_0} + Q.\frac{h}{h_0} = \tfrac{1}{15}.f + P\left(1 + \frac{g - g_0}{g_0}\right) + Q\left(1 + \frac{h - h_0}{h_0}\right)$$

(in time)

$$= \tfrac{1}{15}.f + P(1 + x) + Q(1 + y),$$

and, similarly,

$$\delta' - \delta = I + P'(1 + x) + Q'(1 + y),$$

where

$$x = \frac{g - g_0}{g_0}, \text{ and } y = \frac{h - h_0}{h_0}.$$

I is also tabulated for each degree of declination for values of ι, proceeding by differences of $0''\cdot1$.

The values chosen for g_0 and h_0 are $20''\cdot053$ and $18''\cdot5$ respectively, so that x is generally negative and never greater numerically than unity, while y is always positive and never greater than $0\cdot11$. The terms Px, $P'x$, Qy and $Q'y$ can therefore be easily taken from Crelle's tables.

P, Q, P', Q' are taken from the tables with the argument $G + a$ for P and P', and $H + a$ for Q and Q'. The values for the nearest whole minute of time will generally be amply sufficient in accuracy, but closer interpolation (if desired) is very simple. The increments in the values of P, Q, and Q' for $1°$ of declination are given down the columns, and their variations for every fraction of a degree can be written at once under their tabular values. The signs of the terms are taken from a small table with the arguments $G + a$ and $H + a$; the upper sign, where two occur together, being for northern, and the lower for southern, declinations.

As an example, I give a portion of the table for declination $40°$, in which the small figures at the side of each column give the change of the function for $1°$ of declination:—

40°

	G+a P'/P' ∓	H+a Q/Q' +
XII.—XVIII.	∓	−
XVIII.—XXIV.	∓	+

	G+a P'/P'	H+a Q/Q'
	3·6	2·76 [-4]
	3·7	2·83
	3·8	2·91
	3·9	2·99
	4·0	3·06
	4·1	3·14
	4·2	3·22 [-5]
	4·3	3·29
	…	…
	7·8	5·97 [-9]
	7·9	6·05
	8·0	6·13
	8·1	6·20
	8·2	6·28

↑ VII./XIX.

VIII./XX.

IV./XVI. →	G+a P	H+a Q	H+a Q'	VIII./XX.
0	0·971 [35]	1·394 [21]	5·95 [12]	…
2	0·976	1·401	5·86	58
4	0·981	1·408	5·77	56
6	0·986	1·415	5·67	54
8	0·990 [36]	1·422	5·58	52
10	0·995	1·428	5·49 [11]	50
12	0·999	1·435 [22]	5·40	48
…	…	…	…	…
40	1·054 [38]	1·513 [23]	4·07 [8]	20
42	1·057	1·518	3·97	18
44	1·061	1·522	3·87	16
46	1·064	1·527	3·77	14
48	1·067	1·531	3·67	12
50	1·070	1·535	3·58	10
…	…	…	…	…

	G+a P'/P' +	H+a Q/Q' +
0.—VI.	+	+
VI.—XII.	∓	−

I./XIII. →	G+a P	H+a Q	H+a Q'	XI./XXIII.
0	0·290	0·417	11·49 [24]	…
2	0·300 [11]	0·430 [7]	11·46	58
4	0·309	0·444	11·43	56
6	0·319	0·457	11·40	54
8	0·328 [12]	0·471	11·37	52
10	0·337	0·484	11·34 [23]	50
12	0·347 [13]	0·498	11·31	48
14	0·356	0·511 [8]	11·28	46
16	0·365	0·524	11·24	44
18	0·374	0·537	11·21	42
20	0·384 [14]	0·551	11·17	40
22	0·393	0·564	11·14	38
24	0·402	0·577	11·10	36
26	0·411	0·590 [9]	11·06	34
28	0·420 [15]	0·603	11·03	32
…	…	…	…	…

↑ X./XXII.

Now with this table let us find the star-corrections for—

· Ex. 1. β Bootis, 1889 May 20.

From the American Ephemeris we get for this date—

$$f \text{ (in time)} = + 0^s\cdot114, \ G = 4^h \ 52^m\cdot3, \ H = 13^h \ 50^m\cdot5, \ \iota = - 4''\cdot03,$$

and—

$$x \text{ is found to be } = - \cdot869, \ y = + \cdot084.$$

The computation is then as follows:—

1889 *May* 20.

	h m		h m		
$a = $	14 57·8	$a = $	14 57·8	$\delta = + 40°\ 50'$	
$G = $	4 52·3	$H = $	13 50·5		
$G + a = $	19 50·1	$H + a = $	4 48·3		

R.A.   Dec.

	s		
P_0	0·995	P_0'	$9''26$ (*from separate table*)
δP	30	$P'x$	$-8\cdot05$
sum	1·025		
Px	$-\cdot891$		

$$(1) = - 0^s\cdot134 \qquad\qquad (1) = + 1''21$$

Q_0	1·532	Q_0'	3·67
δQ	19	$\delta Q'$	6
Qy	$+130$	$Q'y$	$+31$

$$(2) = + 1\cdot681 \qquad\qquad (2) = + 4\cdot04$$

f	$(3) = + 0\cdot114$	I	$3\cdot09 - \cdot03$	$(3) = - 3\cdot06$
sum	$+ 1\cdot661$	sum		$+ 2\cdot19$

Ex. 2.   *   1889 March 12.

For this date—

$$f = - 0^s\cdot369, \ G = 9^h \ 5^m\cdot0, \ H = 18^h \ 31^m \ 1, \ \iota = - 8''\cdot08,$$

and—

$$x \text{ is found to be } = - \cdot835, \ y = + \cdot015.$$

	h m		h m		
$a = $	4 8 1	$a = $	4 8·1	$\delta = - 40°\ 24'$	
$G = $	9 5·0	$H = $	18 31·1		
$G + a = $	13 13·1	$H + a = $	22 39·2		

R.A.   Dec.

	s		
P_0	0 352	P_0'	$19''04$ (*from separate table*)
δP	5	$P'x$	$- 15\cdot90$
sum	·357		
Px	$- \cdot298$		

$$(1) = + 0^s\cdot059 \qquad\qquad (1) = - 3''14$$

Q_0	0·557	Q_0'	11·16
δQ	3	$\delta Q'$	9
Qy	8	$Q'y$	17

$$(2) = - 0\cdot568 \qquad\qquad (2) = - 11\cdot42$$

f	$(3) = - 0\cdot369$	I	$6\cdot19 - \cdot04$	$(3) = - 6\cdot15$
sum	$- 0\ 878$	sum		$- 20\cdot71$

The signs are not to be placed before the quantities as taken from the tables, but are inserted before the final values in the last column—viz. after (1), (2), and (3) ; the sign of I is always the same as that of ι.   The quantities δP, δQ, δQ' are the increments of P, Q, Q' for the minutes of declination (in our case 50 for Ex. 1, 24 for Ex. 2), and are always additive if P, Q, and Q' be taken from the table for the nearest degree *numerically* less than the star's declination, while the correction to I is subtractive.

A computation of one pair of these star-corrections with four-figure logarithms would require 160 figures and symbols ; the ordinary method $(Aa+Bb+\&c.)$ requires 217 figures, without taking into account the labour of forming a, b, &c. ; while the result above has been obtained with 110 figures.   This means a very considerable saving of time when we consider that some thousands of these computations have to be made every year. It might be more convenient, in the case of only a few star-corrections being wanted, to have the values of P' given in the tables with the others ; but if many stars are being reduced, the first step would be to run in the values of P' for all of them as soon as the values of $G+a$ are formed.

At declination 60° the change of P for 1° is $0^s\!\cdot096$, which is perhaps too large for δP to be readily written down ; the change of Q is somewhat less ; so that it may be advisable to reduce the intervals of declination for which the tables, after 50°, are computed to half degrees.   As a matter of fact, the star-corrections are practically only required to the nearest hundredth in R.A. and the nearest tenth in declination ; and I do not anticipate any difficulty in using the tables as far as 70°.   They will certainly save much time when the declination is small.

The value chosen for g_0 is the constant n of the precession for the year 1900, so that for many years the precessions in right ascension and declination for any star can be taken at once from the proper declination table with the argument R.A. —viz. $3^s\!\cdot073+P$ and P', due regard being paid to the signs of P and P'.   But, as far as concerns the computation of star-corrections, the tables hold good for all time, any changes in the astronomical constants being taken account of in the data of the Ephemeris and in the values of x and y.

For the most effective use of the tables the values of f, G, H should be given in time and ι in seconds of arc (as is done in the American Ephemeris), and the values of x and y for each day in the year.   These two last might, however, be readily taken from a table proceeding by increments of $0''\!\cdot1$ of g and h.

I may mention that approximate tables of this kind were prepared by means of Crelle's tables, and used for a check-computation of the star-corrections for the *Victoria* and *Sappho* stars observed here last year, and were found to be satisfactory ; but in order to secure accuracy in the last decimal place of the

tables a more exact calculation is necessary. I have made considerable progress in the calculation of accurate tables, and hope soon to have them completed.

Cape of Good Hope :
    1890 *May* 5.

On the Computation of the Equation of the Centre in Elliptical Orbits of Moderate Eccentricities. By A. Marth.

Though the indirect solution of Kepler's problem is a sufficiently easy proceeding when only a limited number of positions have to be computed, it takes rather too much time and becomes tiresome when it has to be repeated periodically hundreds of times. To provide for such cases some method is required for deducing the true anomalies directly from the mean anomalies with the desired degree of accuracy.

To find the true anomalies with the accuracy sufficient for approximate ephemerides of the minor planets, two sets of general tables have been computed: Mr. Godward's "Auxiliary Tables for Computing an Approximate Ephemeris of a Minor Planet" . . . printed 1866, and used in the *Nautical Almanac* office, and MM. Callandreau and Fabry's "Tables numériques destinées a faciliter le calcul des éphémerides" . . . published, 1885, in the second volume of the *Bulletin Astronomique*.

To get the true anomalies with an accuracy required for closer computations, the late E. Schubert gives in his later tables and papers on the elements of the minor planets a special "Table for the correction to be added to the auxiliary anomaly v'," this v' being found by the equation

$$\cot \tfrac{1}{2} v' = \frac{1-e}{1+e} \cot \tfrac{1}{2} \text{ mean anomaly.}$$

The present paper is intended to furnish the means for facilitating the calculation of certain tables, which will allow the differences between the true and mean anomalies to be easily deduced, whenever the intended work may make the construction of such tables desirable.

If e denotes the eccentricity, μ and v the mean and true anomaly, ω the angular value of the radius, the equation of the centre is given by the known series (all terms to e^{10} inclusive being retained) as follows :—

$$v - \mu = \quad 2\omega\left(1 - \frac{1}{8}e^2 + \frac{5}{192}e^4 + \frac{107}{9216}e^6 + \frac{6217}{737280}e^8 + \ldots\right) . \, e \sin \mu.$$

$$+ \frac{5}{4}\omega\left(1 - \frac{11}{30}e^2 + \frac{17}{240}e^4 + \frac{43}{7200}e^6 + \frac{677}{86400}e^8 + \ldots\right) . \, e^2 \sin 2\mu.$$

$$+ \frac{13}{12}\omega\left(1 - \frac{129}{208}e^2 + \frac{285}{1664}e^4 - \frac{973}{66560}e^6 + \quad \ldots\right) . \, e^3 \sin 3\mu.$$

$$+ \frac{103}{96}\omega\left(1 - \frac{451}{515}e^2 + \frac{4123}{12360}e^4 - \frac{1619}{25956}e^6 + \ldots\right) . \, e^4 \sin 4\mu.$$

$$+ \frac{1097}{960}\omega\left(1 - \frac{29785}{26328}e^2 + \frac{824605}{1474368}e^4 - \ldots\right) . \, e^5 \sin 5\mu.$$

$$+ \frac{1223}{960}\omega\left(1 - \frac{23739}{17122}e^2 + \frac{116265}{136976}e^4 - \quad \ldots\right) . \, e^6 \sin 6\mu.$$

$$+ \frac{47273}{32256}\omega\left(1 - \frac{12412897}{7563680}e^2 + \ldots\right) . \, e^7 \sin 7\mu.$$

$$+ \frac{556403}{322560}\omega\left(1 - \frac{9490966}{5007627}e^2 + \ldots\right) . \, e^8 \sin 8\mu.$$

$$+ \frac{10661993}{5160960}\omega . \, e^9 \sin 9\mu + \frac{7281587}{2903040}\omega . \, e^{10} \sin 10\mu + \ldots$$

$$= k_1 . \, e \sin \mu + k_2 . \, e^2 \sin 2\mu + k_3 . \, e^3 \sin 3\mu + k_4 . \, e^4 \sin 4\mu + \ldots$$

$$= k_1 . \, e \sin \mu . (1 + \kappa . \, e \cos \mu) + k_3 . \, e^3 \sin 3\mu + k_4 . \, e^4 \sin 4\mu + \ldots$$

where $\kappa = \frac{5}{4}\left(1 - \frac{29}{120}e^2 + \frac{7}{480}e^4 + \frac{571}{230400}e^6 + \frac{23657}{11059200}e^8\right).$

If a table containing the values of

$$k_3 . \, e^3 \sin 3\mu + k_4 . \, e^4 \sin 4\mu + \ldots$$

were prepared, the equation of the centre would be found by computing $k_1 . \, e \sin \mu \, (1 + \kappa . \, e \cos \mu)$ for each individual mean anomaly, and adding the corresponding tabular value representing the remainder of the series. However, as this remainder would be obviously smaller in a series in which the first term, instead of being multiplied by a factor $1 + \kappa e \cos \mu$, had a divisor of the form $1 - ce \cos \mu$, it will clearly be of advantage to convert the series for the equation of the centre into another, beginning with a term of the form

$$\frac{Ce \sin \mu}{1 - ce \cos \mu},$$

in which the values of C and c are so determined that the first two terms of the old series are incorporated in the new expression. These values are accordingly to be found.

$$\frac{\sin \mu}{1 - ce \cos \mu} = \sin \mu \, (1 + ce \cos \mu + c^2 e^2 \cos^2 \mu + c^3 e^3 \cos^3 \mu + c^4 e^4 \cos^4 \mu + \ldots)$$

But

$$4 \sin \mu \cos^2\mu = \quad \sin \mu + \quad \sin 3\mu.$$

$$16 \sin \mu \cos^4\mu = 2 \sin \mu + 3 \sin 3\mu + \quad \sin 5\mu.$$

$$64 \sin \mu \cos^6\mu = 5 \sin \mu + 9 \sin 3\mu + 5 \sin 5\mu + \quad \sin 7\mu.$$

$$256 \sin \mu \cos^8\mu = 14 \sin \mu + 28 \sin 3\mu + 20 \sin 5\mu + 7 \sin 7\mu + \sin 9\mu.$$

$$8 \sin \mu \cos^3\mu = 2 \sin 2\mu + \quad \sin 4\mu.$$

$$32 \sin \mu \cos^5\mu = 5 \sin 2\mu + 4 \sin 4\mu + \quad \sin 6\mu.$$

$$128 \sin \mu \cos^7\mu = 14 \sin 2\mu + 14 \sin 4\mu + 6 \sin 6\mu + \quad \sin 8\mu.$$

$$512 \sin \mu \cos^9\mu = 42 \sin 2\mu + 48 \sin 4\mu + 27 \sin 6\mu + 8 \sin 8\mu + \sin 10\mu.$$

Hence, putting for greater simplicity $ce = 2\eta$,

$$\frac{\sin \mu}{1 - ce \cos \mu} = (1 + \eta^2 + 2\eta^4 + 5\eta^6 + 14\eta^8 + \ldots) \cdot \sin \mu.$$

$$+ (1 + 2\eta^2 + 5\eta^4 + 14\eta^6 + 42\eta^8 + \ldots) \cdot \eta \sin 2\mu.$$

$$+ (1 + 3\eta^2 + 9\eta^4 + 28\eta^6 + \ldots) \cdot \eta^2 \sin 3\mu.$$

$$+ (1 + 4\eta^2 + 14\eta^4 + 48\eta^6 + \ldots) \cdot \eta^3 \sin 4\mu.$$

$$+ (1 + 5\eta^2 + 20\eta^4 + \ldots) \cdot \eta^4 \sin 5\mu.$$

$$+ (1 + 6\eta^2 + 27\eta^4 + \ldots) \cdot \eta^5 \sin 6\mu.$$

$$+ (1 + 7\eta^2 + \ldots) \cdot \eta^6 \sin 7\mu.$$

$$+ (1 + 8\eta^2 + \ldots) \cdot \eta^7 \sin 8\mu + \eta^8 \sin 9\mu + \eta^9 \sin 10\mu + \ldots$$

and therefore

writing θ for $\eta (1 + \eta^2 + 2\eta^4 + 5\eta^6 + 14\eta^8 + \ldots)$,

$$\frac{Ce \sin \mu}{1 - ce \cos \mu} = \frac{2C}{c} (\theta \sin \mu + \theta^2 \sin 2\mu + \theta^3 \sin 3\mu + \theta^4 \sin 4\mu + \ldots).$$

The value of c must accordingly be so chosen that

$$\theta = \frac{k_2}{k_1} \cdot e = \frac{5}{8} e \left(1 - \frac{29}{120} e^2 + \frac{7}{480} e^4 + \frac{571}{230400} e^6 + \frac{23657}{11059200} e^8 \right),$$

and C so that

$$\frac{2C}{c} \cdot \theta = k_1.$$

The determination of the two values which satisfy these conditions gives—

$$C = 2\omega \left(1 - \frac{33}{64} e^2 + \frac{1705}{4096} e^4 - \frac{666617}{2359296} e^6 + \frac{18106717}{83886080} e^8 \ldots \right).$$

$$e = \frac{5}{4} \left(1 - \frac{607}{960} e^2 + \frac{27671}{61440} e^4 - \frac{19289249}{58982400} e^6 + \frac{2688060283}{11324620800} e^8 \ldots \right).$$

Hence follows—

$$\frac{Ce \sin \mu}{1 - ce \cos \mu} = 2\omega \left(1 - \frac{1}{8} e^2 + \frac{5}{192} e^4 + \frac{107}{9216} e^6 + \frac{6217}{737280} e^8 + \ldots \right) . e \sin \mu.$$

$$+ \frac{5}{4} \omega \left(1 - \frac{11}{30} e^2 + \frac{17}{240} e^4 + \frac{43}{7200} e^6 + \frac{677}{86400} e^8 + \ldots \right) . e^2 \sin 2\mu.$$

$$+ \frac{25}{32} \omega \left(1 - \frac{73}{120} e^2 + \frac{1253}{7200} e^4 - \frac{3229}{230400} e^6 \ldots \right) . e^3 \sin 3\mu.$$

$$+ \frac{125}{256} \omega \left(1 - \frac{17}{20} e^2 + \frac{537}{1600} e^4 - \frac{107939}{1728000} e^6 \ldots \right) . e^4 \sin 4\mu.$$

$$+ \frac{625}{2048} \omega \left(1 - \frac{131}{120} e^2 + \frac{889}{1600} e^4 \ldots \right) . e^5 \sin 5\mu.$$

$$+ \frac{3125}{16384} \omega \left(1 - \frac{4}{3} e^2 + \frac{1201}{1440} e^4 \ldots \right) . e^6 \sin 6\mu.$$

$$+ \frac{15625}{131072} \omega \left(1 - \frac{63}{40} e^2 \ldots \right) . e^7 \sin 7\mu.$$

$$+ \frac{78125}{1048576} \omega \left(1 - \frac{109}{60} e^2 \ldots \right) . e^8 \sin 8\mu.$$

$$+ \frac{390625}{8388608} \omega . e^9 \sin 9\mu + \frac{1953125}{67108864} \omega . e^{10} \sin 10\mu + \ldots$$

the substitution of which in the old series for the equation of the centre furnishes the new series

$$v - \mu = \frac{Ce \sin \mu}{1 - ce \cos \mu} + \{ c_3 e^3 \sin 3\mu + c_4 e^4 \sin 4\mu + \ldots c_{10} e^{10} \sin 10\mu \},$$

in which the coefficients $c_3, c_4, c_5 \ldots$ have the following values

$$c_3 = \frac{29}{96} \omega \left(1 - \frac{151}{232} e^2 + \frac{457}{2784} e^4 - \frac{7207}{445440} e^6 \ldots \right).$$

$$c_4 = \frac{449}{768} \omega \left(1 - \frac{8057}{8980} e^2 + \frac{143047}{431040} e^4 - \frac{300761}{4827648} e^6 \ldots \right).$$

$$c_5 = \frac{25729}{30720} \omega \left(1 - \frac{707495}{617496} e^2 + \frac{19386485}{34579776} e^4 \ldots \right).$$

$$c_6 = \frac{266213}{245760} \omega \left(1 - \frac{2601092}{1863491} e^2 + \frac{152311165}{178895136} e^4 \ldots \right).$$

$$c_7 = \frac{11117513}{8257536} \omega \left(1 - \frac{732409783}{444700520} e^2 \ldots \right).$$

$$c_8 = \frac{545147297}{330301440} \omega \left(1 - \frac{37265543611}{19625302692} e^2 \ldots \right).$$

$$c_9 = \frac{5335893541}{2642411520} \omega.$$

$$c_{10} = \frac{471668976257}{190253629440} \omega.$$

A comparison of these values with the values of the corresponding coefficients of the old series shows the advantage of the new series in the diminution of the coefficients.

The logarithms of the coefficients are, if m is the modulus,

$$\log C = \log 2\,\omega - \frac{33}{64}m \cdot e^2 + \frac{2321}{8192}m \cdot e^4 - \frac{268043}{2359296}m \cdot e^6 + \frac{77029999}{1006632960}m \cdot e^8.$$

$$\log c = \log \frac{5}{4} - \frac{607}{960}m \cdot e^2 + \frac{461681}{1843200}m \cdot e^4 - \frac{335831383}{2654208000}m \cdot e^6$$
$$+ \frac{235312199009}{3397386240000}m \cdot e^8.$$

$$\log c_3 = \log\left(\frac{29}{96}\omega\right) - \frac{151}{232}m \cdot e^2 - \frac{15391}{322944}m \cdot e^4 - \frac{466537}{374615040}m \cdot e^6.$$

$$\log c_4 = \log\left(\frac{449}{768}\omega\right) - \frac{8057}{8980}m \cdot e^2 - \frac{68350979}{967684800}m \cdot e^4 - \frac{21481600365\,1}{40552444352000}m \cdot e^6.$$

$$\log c_5 = \log\left(\frac{25729}{30720}\omega\right) - \frac{707495}{617496}m \cdot e^2 - [8 \cdot 98109]m \cdot e^4.$$

$$\log c_6 = \log\left(\frac{266213}{245760}\omega\right) - \frac{2601092}{1863491}m \cdot e^2 - [9 \cdot 08903]m \cdot e^4.$$

or numerically, if ω is expressed in degrees,

$$\log C = 2 \cdot 059152628 - [9 \cdot 3501183]e^2 + [9 \cdot 0900695]e^4 - [8 \cdot 69321]e^6$$
$$+ [8 \cdot 52157]e^8.$$

$$\log c = 0 \cdot 096910013 - [9 \cdot 4387018]e^2 + [9 \cdot 0365539]e^4 - [8 \cdot 73997]e^6$$
$$+ [8 \cdot 47828]e^8.$$

$$\log c_3 = 1 \cdot 2382494 - [9 \cdot 4512733]e^2 - [8 \cdot 31592]e^4 - [6 \cdot 73309]e^6.$$

$$\log c_4 = 1 \cdot 5250078 - [9 \cdot 5906814]e^2 - [8 \cdot 48680]e^4 - [7 \cdot 36183]e^6.$$

$$\log c_5 = 1 \cdot 6811243 - [9 \cdot 6968735]e^2 - [8 \cdot 61887]e^4.$$

$$\log c_6 = 1 \cdot 7928407 - [9 \cdot 7826127]e^2 - [8 \cdot 72682]e^4.$$

$$\log c_7 = 1 \cdot 88728 - [9 \cdot 8545]e^2.$$

$$\log c_8 = 1 \cdot 97573 - [9 \cdot 9163]e^2.$$

$$\log c_9 = 2 \cdot 06333.$$

$$\log c_{10} = 2 \cdot 15243.$$

Instead of the coefficients of e^2 . . . their logarithms are given enclosed in [ ] brackets, 10 being added to the characteristics.

If the values of C, c_3, c_4 . . . are required to be expressed in seconds, log 3600 must be added to the first terms, which become thus—

$$\log C = 5 \cdot 615455129 - \ldots \qquad\qquad \log c_5 = 5.2374268 - \ldots$$

$$\log c_3 = 4 \cdot 7945519 \quad - \ldots \qquad\qquad \log c_6 = 5 \cdot 3491432 - \ldots$$

$$\log c_4 = 5 \cdot 0813103 \quad - \ldots \qquad\qquad \log c_7 = 5 \cdot 44358.$$

I have given all terms to e^{10} inclusive, so that, if needed, they may be taken into account. The following table contains, for various values of log e, the values of the coefficients $c_7 e^7$, $c_8 e^8$, $c_9 e^9$, $c_{10} e^{10}$ expressed in degrees and also in seconds.

Coefficients expressed

log e	c_7e^7	In Degrees. c_8e^8	c_9e^9	$c_{10}e^{10}$	c_7e^7	In Seconds of Arc. c_8e^8	c_9e^9	$c_{10}e^{10}$
9·00	0·000008	·00001	...	...	0·03	0·003	"	"
·02	010	001	...	...	·04	·005	...	...
·04	014	002	...	...	·05	·007	...	...
·06	020	003	...	...	·07	·010	...	...
·08	027	004	...	...	·10	·014	...	...
9·10	·000038	·000006	001	...	0·14	0·021	0·003	...
·12	052	008	001	...	·19	·030	·005	...
·14	071	012	002	...	·26	·043	·008	...
·16	098	017	003	...	·35	·062	·011	...
·18	135	025	005	...	·49	·090	·017	...
9·20	·000186	·000036	007	001	0·67	0·13	0·026	0·005
·22	256	052	011	002	0·92	·19	·040	·008
·24	351	074	017	004	1·26	·27	·060	·013
·26	483	107	025	006	1·74	·38	·091	·020
·28	663	153	038	009	2·39	·55	·14	·03
9·30	·000909	·000220	058	014	3·27	0·79	0·21	0·05
·32	·001248	316	088	023	4·49	1·14	0·32	0·08
·34	·001710	453	133	036	6·16	1·63	0·48	0·13
·36	·002343	649	201	057	8·43	2·34	0·72	0·20
·38	·003207	930	304	090	11·55	3·35	1·10	0·32
9·40	0·004387	·001330	461	142	15·79	4·79	1·66	0·51

In case the desired accuracy allows the neglect of $c_7e^7 \sin 7\mu$, the computation of the tabular values of

$$\{c_8\,e^8 \sin 3\mu + c_4\,e^4 \sin 4\mu + c_8\,e^8 \sin 5\mu + c_8\,e^8 \sin 6\mu\}$$

for any value of log *e* and for each degree of μ is easily accomplished, if the required log sines of the multiples of μ are specially written out beforehand, so that the $30 + 22 + 18 + 15$ numerical values, which enter into combination, may be quickly computed.

If that is done for conveniently altered values of log *e*, the variation of the eccentricity may be easily taken into account. To save all trouble in computing the coefficients, their logarithms for suitable values of log *e* are supplied by the following tables.

In the computation of

$$\frac{Ce \sin \mu}{1 - ce \cos \mu}$$

the values of log C and log *c* must be properly interpolated to correspond to the varied values of log *e*. Want of space did not permit the differences of successive values to be given on the last pages.

Q Q 2

log e	log C		log c		log $c_i e^2$	log $c_i e^4$	log $c_i e^6$
8·00	2·059 1302	21	0·096 8826	27	5·238		
·02	1381	24	8799	29	5·298		
·04	1257	26	8770	32	5·358		
·06	1231	28	8738	35	5·418		
·08	1203	32	8703	38	5·478		
8·10	2·059 1171	34	0·096 8665	42	5·538		
·12	1137	37	8623	46	5·598		
·14	1100	42	8577	51	5·658		
·16	1058	45	8426	55	5·718		
·18	1013	49	8471	61	5·778		
8·20	2·059 0964	54	0·096 8410	66	5·8382		
·22	0910	60	8344	73	5·8982		
·24	0850	65	8271	80	5·9582		
·26	0785	72	8191	88	6·0182		
·28	0713	78	8103	96	6·0781		
8·30	2·059 0635	86	0·096 8007	105	6·1381	4·725	
·32	0549	94	7902	116	6·1981	4·805	
·34	0455	104	7786	127	6·2581	4·885	
·36	0351	113	7659	139	6·3181	4·965	
·38	0238	124	7520	152	6·3781	5·045	
8·40	2·059 0114	136	0·096 7368	167	6·4381	5·125	
·42	·058 9978	150	7101	183	6·4981	5·205	
·44	9828	164	7018	201	6·5580	5·285	
·46	9664	179	6817	220	6·6180	5·365	
·48	9485	197	6597	242	6·6780	5·445	
8·50	2·058 9288	216	0·096 6355	265	6·7380	5·525	
·52	9072	236	6090	290	6·7979	5·605	
·54	8836	260	5800	318	6·8579	5·685	
·56	8576	284	5482	349	6·9179	5·764	
·58	8292	312	5133	382	6·9778	5·844	
8·60	2·058 7980	342	0·096 4751	420	7·0378	5·9244	4·680
·62	7638	374	4331	459	7·0978	6·0043	4·780
·64	7264	411	3872	504	7·1577	6·0843	4·880
·66	6853	450	3368	553	7·2177	6·1642	4·980
·68	6403	494	2815	606	7·2776	6·2441	5·080
8·70	2·058 5909	541	0·096 2209	664	7·3375	6·3240	5·180
·72	5368	593	1545	728	7·3975	6·4039	5·280
·74	4775	650	0817	798	7·4574	6·4838	5·380
·76	4125	713	·096 0019	875	7·5173	6·5637	5·479
·78	3412	781	·095 9144	959	7·5772	6·6436	5·579
8·80	2·0·8 2631		0·095 8185		7·6371	6·7235	5·679

log e	log O	log c	log $c_s e^s$	log $c_s e^s$	log $e_s e^s$	log $r_s e^s$
8·80	2·058 2631	0·095 8185	7·6371	6·7235	5·679	4·590
·81	·058 2213	·095 7672	7·6671	6·7634	5·729	4·650
·82	·058 1775	·095 7134	7·6970	6·8033	5 779	4·710
·83	·058 1316	·095 6571	7·7270	6·8432	5·829	4·770
·84	·058 0836	·095 5982	7·7569	6·8831	5·879	4·830
8·85	2·058 0334	0·095 5365	7·7868	6·9231	5·929	4·890
·86	·057 9808	·095 4719	7·8168	6·9630	5·9785	4·950
·87	·057 9257	·095 4042	7·8467	7·0029	6·0284	5·010
·88	·057 8681	·095 3334	7·8766	7·0428	6·0783	5·069
·89	·057 8078	·095 2593	7·9065	7·0827	6·1281	5·129
8·90	2·057 7446	0·095 1817	7·9365	7·1225	6·1780	5·189
·91	·057 6785	·095 1005	7·9664	7·1624	6·2278	5·249
·92	·057 6093	·095 0154	7·9963	7·2c23	6·2777	5·309
·93	·057 5368	·094 9264	8·02620	7·2422	6·3275	5·368
·94	·057 4610	·094 8332	8·05610	7·2820	6·3773	5·428
8·95	2·057 3816	0·094 7356	8·08600	7·3219	6·4272	5·488
·96	·057 2985	·094 6335	8 11590	7·3618	6·4770	5·548
·97	·057 2116	·094 5266	8·14579	7·4016	6·5270	5·608
·98	·057 1205	·094 4146	8·17567	7·4415	6·5766	5·667
8·99	·057 0253	·094 2975	8·20555	7·4813	6·6264	5·727
9·00	2·056 9256	0·094 1748	8·23542	7 5211	6·6761	5·787
·01	·056 8212	·094 0465	8·26529	7·5609	6·7259	5·846
·02	·056 7120	·093 9121	8·29515	7·6007	6·7757	5·906
·03	·056 5977	·093 7714	8·32500	7·6405	6·8254	5·966
·04	·056 4781	·093 6242	8·35485	7·803	6 8751	6·0255
9·05	2·056 3529	0·093 4701	8·38469	7·7201	6·9249	6·0852
·06	·056 2219	·093 3089	8·41452	7·7599	6·9746	6 1448
·07	·056 0848	·093 1401	8·44434	7·7996	7·0242	6·2045
·08	·055 9414	·092 9634	8·47416	7·8394	7·0739	6·2641
·09	·055 7913	·092 7785	8·50396	7·8791	7·1236	6·3237
9·10	2·055 6342	0·092 5850	8·53376	7·9188	7·1732	6 3832
·11	·055 4699	·092 3825	8·56355	7·9585	7·2229	6·4428
·12	·055 2980	·092 1706	8·59333	7·99823	7·2725	6·5023
·13	·055 1182	·091 9488	8·62310	8·03791	7·3221	6·5618
·14	·054 9300	·091 7167	8·65286	8 07757	7·3716	6 6213
9·15	2·054 7332	0 091 4739	8·68260	8 11722	7·4212	6·6807
·16	·c54 5273	·091 2198	8·71233	8·15685	7·4707	6·7402
·17	·054 3119	·090 9539	8·74205	8·19647	7·5202	6·7996
·18	·054 08·6	·090 6757	8·77176	8·23607	7·5697	6·8589
·19	·053 8510	·090 3846	8·80146	8·27564	7·6192	6·9183
9·20 ·	2·053 6046	0·090 0801	8·83114	8·31520	7 6·86	6·9776

log e	log O	log c	log c_1e^2	log c_2e^4	log c_3e^5	log c_4e^6
9·200	2·053 6046	0·090 0801	8·83114	8·31520	7·6686	6·9776
·205	·053 4771	·089 9226	8·84597	8·33497	7·6933	7·0072
·210	·053 3468	·089 7615	8·86080	8·35474	7·7180	7·0369
·215	·053 2136	·089 5968	8·87563	8·37450	7·7427	7·0665
·220	·053 0773	·089 4283	8·89045	8·39425	7·7674	7·0961
·225	·052 9380	·089 2559	8·90527	8·41400	7·7921	7·1257
·230	·052 7955	·089 0796	8·92008	8·43374	7·8167	7·1553
·235	·052 6498	·088 8993	8·93489	8 45348	7·8414	7·1849
·240	·052 5008	·088 7149	8·94969	8·47321	7·8661	7·2145
·245	·052 34ˣ5	·088 5263	8 96449	8·49294	7·8907	7·2441
9·250	2·052 1928	0·088 3334	8·97929	8·51266	7·9153	7·2736
·255	·052 0335	·088 1362	8·994081	8·53237	7·9400	7·3032
·260	·051 8707	·087 9344	9·008867	8·55207	7·9646	7·3327
·265	·051 7042	·087 7281	9·023648	8·57177	7·9892	7·3622
·270	·051 5340	·087 5171	9·038423	8·59146	8·01382	7·3918
·275	·051 3599	·087 3013	9·053194	8 61114	8·03842	7·4213
·280	·051 1820	·087 0807	9·067959	8·63082	8·06300	7·4508
·285	·051 0001	·086 8550	9·082719	8·65049	8·08758	7·4802
·290	·050 8141	·086 6243	9·097473	8·67015	8·11215	7·5097
·295	·050 6240	·086 3883	9·112221	8·68980	8·13670	7·5392
9·300	2·050 4297	0·086 1470	9·126963	8·70945	8·16125	7·5686
·305	·050 2310	·085 9002	9·141700	8·72908	8·18578	7·5981
·310	·050 0279	·085 6479	9·156430	8·74871	8·21031	7·6275
·315	·049 8203	·085 3899	9·171154	8·76833	8·23482	7·6569
·320	·049 6081	·085 1261	9·185871	8·78794	8·25932	7·6863
·325	·049 3911	·084 8563	9·200582	8·80754	8·28381	7·7157
·330	·049 1694	·084 5805	9·215286	8·82713	8·30829	7·7450
·335	·048 9428	·084 2985	9·229983	8·84671	8·33276	7·7744
·340	·048 7112	·084 0101	9·244673	8·86629	8·35721	7·8037
·345	·048 4744	·083 7153	9·259355	8·88585	8·38165	7·8330
9 350	2 048 2325	0·083 4139	9·274030	8·90540	8·40608	7·8623
·355	·047 9852	·083 1057	9·288698	8·92494	8·43050	7·8916
·360	·047 7325	·082 7906	9·303358	8·94447	8·45490	7·9209
·365	·047 4742	·082 4685	9·318010	8·96399	8·47928	7·9501
·370	·047 2103	·082 1392	9·332653	8·98360	8·50365	7·9794
·375	·046 9406	·081 8026	9·347288	9·002998	8·52801	8·00858
·380	·046 6650	·081 4584	9·361915	9·022483	8·55235	8·03778
·385	·046 3834	·081 1066	9·376633	9·041956	8·57668	8·06696
·390	·046 0957	·080 7470	9·391142	9·060417	8·60099	8·09612
·395	·045 8017	·080 3794	9·405742	9·080865	8·62528	8·12526
9·400	2 045 5014	0·080 0036	9·420332	9·100299	8·64956	8·15438

A simple Solution of Kepler's Problem. By A. Marth.

What is Kepler's problem ? Is it the problem to find the eccentric from the mean anomaly *by means* of Kepler's equation ? Or is it the problem to find somehow the eccentric anomaly which will *satisfy* that equation ?

The simple method, which I now offer, for computing the eccentric anomaly ϵ from the mean anomaly μ, consists in substituting for Kepler's equation $\epsilon - \mu = e \sin \epsilon$ an equivalent equation, the solution of which is free from the difficulties with which that of Kepler's equation is beset, and which is derived from the latter by an extremely simple process.

The multiplication of

$$\epsilon - \mu = e \sin \epsilon \text{ by } \frac{\sin (\epsilon - \mu)}{\epsilon - \mu}$$

gives

$$\sin \epsilon \cos \mu - \cos \epsilon \sin \mu = e \sin \epsilon \cdot \frac{\sin (\epsilon - \mu)}{\epsilon - \mu};$$

Hence

$$\tan \epsilon = \frac{\sin \mu}{\cos \mu - e \cdot \dfrac{\sin (\epsilon - \mu)}{\epsilon - \mu}}$$

or

$$\tan \epsilon = \frac{\sin \mu}{\cos \mu - \dfrac{e}{\nu}}$$

if

$$\frac{1}{\nu} = \frac{\sin (e \sin \epsilon)}{e \sin \epsilon}$$

$$= 1 - \frac{e^2 \sin^2 \epsilon}{6} + \frac{e^4 \sin^4 \epsilon}{120} - \frac{e^6 \sin^6 \epsilon}{5040} + \frac{e^8 \sin^8 \epsilon}{362880} - \frac{e^{10} \sin^{10} \epsilon}{39916800} + \ldots$$

The equation $\mu = \epsilon - e \sin \epsilon$ retains its value for computing μ from ϵ, and may thus serve as a control upon the determination of $\tan \epsilon$. Except for the purpose of such control, the angle ϵ itself is not required.

The system of formulæ for deducing the true anomaly v and the radius vector ρ from the mean anomaly μ becomes

$$\left.\begin{array}{l} \tan \epsilon = \dfrac{\sin \mu}{\cos \mu - \dfrac{e}{\nu}} \\[3ex] \rho \sin v = \sin \epsilon \cdot \sqrt{1 - e^2} \\[1ex] \rho \cos v = \cos \epsilon - e. \end{array}\right\}$$

The values of log ν corresponding to log ($e \sin \epsilon$) will be given in a table in the next number of the *Monthly Notices*.

*On the Verification of the Constants employed in the Uranometria
Nova Oxoniensis.* By the Rev. Professor Pritchard, D.D.,
F.R.S.

In the *Monthly Notices* of March last Dr. Spitta throws some
doubt as to the method employed in determining the coefficient
of absorption of the Wedge Photometer used for the purposes of
the Uranometria Oxoniensis. If I understand his criticism
correctly, he doubts whether a proper diaphragm was applied to
the Nicol prism in the apparatus constructed for deriving the
coefficient aforesaid. He found, it appears, that in his own case
the proper use of a proper diaphragm removed some sources of
error, and that he thereby secured results coincident with others
obtained by a different photometric process which he regards as
free from error.

With regard to the accuracy of the two Oxford wedges de-
scribed in the *Memoirs R.A.S.*, vol. xlvii., and used for the
purposes of the Uranometria, I had in effect but little anxiety.
These wedges are of very different steepness, and the coefficient
of absorption of each was independently obtained from nearly
three thousand distinct measures;[*] for I was more anxious to
secure accuracy than to save time usefully expended. Still,
after Dr. Spitta's remark, I felt it my duty to re-examine one of
the two wedges; and I duly attended to his remarks as to the
necessity of using a proper diaphragm in order to obviate the
internal and other reflections which he regards as the source of
error in his own case. The result was that no correction could
possibly be made in the coefficient of absorption of the wedge
used for the Oxford Uranometria. The method employed for
the re-examination of this wedge was an improvement on that
used in 1882, and one whereby any accumulation of small errors
was avoided; which errors, if they existed, would arise from the
smallness of the interval of the wedge, examined step by step
by the old process of 1882. In fact it was to avoid these possible
errors, which led to the employment of so many thousand
applications of the instrument.

The results obtained by the two distinct methods of examin-
ation for the absorption (expressed in stellar magnitude) at each
successive inch of the wedge is shown below.

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[*] Moreover, I had observed that the Nicol Prism employed for obtaining
this constant, was perfectly free from stilbite, or other silicates, and allowed
no light whatever, perceptible to the eye, to pass through it when in the posi-
tion of zero. I may here add, too, that a very scrupulous examination was
instituted in regard to the absorptive power of the wedge in the case of red,
orange, green, and blue lights. The absorptive power was practically the
same for them all. See *Memoirs Roy. Ast. Soc.*, vol. xlvii. p. 395.

Inch.	1882. Mag.	1890. Mag.
1	1·93	1·93
2	3·81	3·89
3	5·69	5·62
4	7·52	7·53
5	9·30	9·41
6	11·07	10·95

Experiments were also made to ascertain the effects of diminishing the aperture of the diaphragm used between the eye and the Nicol. The result was that, as used at Oxford, any material alteration in the diameter of this aperture introduced errors which had not existed before. In order that no mistake should be made in the question of diaphragm, the assistance of Mr. Selby, the demonstrator in the Clarendon Physical Laboratory at Oxford, was invoked, and his independent conclusions coincided with those of Mr. Plummer and Mr. Jenkins.

I take it, therefore, that the coefficients of absorption of the two Oxford wedges are, so far, established as correct. But this is by no means the whole of the case.

Dr. Spitta's objections in reality do not apply solely, or even particularly, to the Wedge Photometer, but to every species of photometrical measure hitherto made by means of the properties of polarised light. They implicitly apply to instruments used by Zöllner, Lindemann, Ceraski, Pickering, and other physicists; but inasmuch as Dr. Spitta finds that on the use of proper precautions the method of polarisation does give the same results as those arising from what he regards as superior methods, I need say no more on the generic question of the instrument or the method used for the evaluation of the coefficient of absorption of a wedge.

I may add also that, in order to extend my own work to stars too faint for the two wedges hitherto used in the Oxford Observatory, I had requested Mr. Hilger to undertake the formidable task of constructing as thin a wedge as he, with all his skill, could effect. In due time I received this excellent instrument, and I found it now applicable to the extinction of stars of mag. $11\frac{1}{2}$, as used with the Oxford $12\frac{1}{4}$-inch object-glass. I proceeded to evaluate its coefficient of absorption by the new and improved method adopted by Professor Pickering (*Investigations on Light and Heat*, No. vi. p. 323). The result was that an interval of one inch extinguished 0·97 mag. I had previously requested Dr. Spitta kindly to evaluate the same wedge constant with his best care and his best methods. His result was that 1·12 mag. was extinguished at each successive inch of the wedge. Armed with these constants, this thin wedge was applied to the heavens, and Mr. Plummer carefully observed thirty stars of the *Pleiades* from magnitude 7 to 11. The resulting magnitudes

were compared with those assigned by Professor Pickering (*Annals Harvard Observatory*, vol. xviii. pt. vii.), and it was found that the average difference of magnitude (Harvard — Oxford) was only 0·07 mag. But, on the other hand, if I used the instrumental determination furnished by Dr. Spitta, the difference between the Harvard and Oxford magnitude would amount to as much as 0·54 mag. Such a difference is wholly unknown in any comparison of my works with those of the most eminent observers.

Again, a similar process was adopted with regard to twenty stars observed by Lindemann.[*] The result here was that with the Oxford value of absorption the average difference (Lindemann —Oxford) amounted to only −0·05 mag. With Dr. Spitta's constant this difference is increased from 0·05 to 0·50 mag. The photometer used by Professor Pickering was his own meridian photometer, aided by photography. Dr. Lindemann used the ordinary Zöllner photometer.

I think that here also I may properly appeal to the results which Dr. Lindemann and Professor Pickering have themselves deduced and recorded from the Oxford photometry. The former says: " From thirty-three stars of the *Pleiades* the mean deviation of a single determination of relative brilliancy equals (Pr—Lind) +0·05 mag." [†] The latter, from the more extensive comparison with the Uranometria Oxoniensis, says: " The mean result from the 2647 stars compared is, that the average magnitude of a star in the U. O. exceeds the corresponding magnitude in the H. P. by 0·049 mag." [‡]

It appears, then, from the foregoing remarks, that both Lindemann and Pickering agree in their results with the Oxford determinations. Each of these employed a method and an instrument of his own, differing from each other and from the method employed at Oxford; and, moreover, this agreement among the three astronomers would be completely destroyed if Dr. Spitta's constant of absorption were adopted.

Nevertheless, I beg to express my sincere obligations to the latter gentleman for his inducing me to re-examine the whole question of wedge photometry, and I hope also he will permit me to acknowledge my admiration of the perseverance and ingenuity with which he has carried on his own investigation.

University Observatory, Oxford:
    1890 *June* 12.

Note on the Scaling of Dr. Spitta's Wedge by means of Photography.
By Captain W. de W. Abney, C.B., D.C.L., F.R.S.

Two or three meetings ago Dr. Spitta read a paper on the scaling of his wedge as used for astronomical purposes, and in the discussion which followed I said that wedges could also be scaled photographically. The scaling, I need scarcely say, referred to the determination of the absorption coefficient per unit of length. Dr. Spitta kindly placed his wedge at my disposal, and I must premise that until I had more than half completed my experiments I had no idea what the coefficient he had determined was, nor the unit of length for which he took it. On subsequently reading his paper in the *Monthly Notices*, I was still at a loss to know these points, as he had not expressly stated the latter, and had to ask him by letter what they were. The wedge he lent me is one cut out of what I suppose ought to be neutral tint, but which is really a species of bottle-green glass. Examining it in the spectrum it was easy to see that there was a much larger absorption coefficient in the red than in the green, and in the green than in the blue-green. Beyond that, it was unnecessary to examine the wedge in this manner. My first experiment was to determine its absorption for the rays which act on iron salts, the maximum of which lies in the blue-green rays. For this purpose I employed the ordinary platinum paper supplied by the Platinotype Company. A strip was placed in contact with the wedge and exposed to the direct light from an arc electric light, care being taken to prevent any light penetrating through the sides of it. The light was placed at such a distance from the wedge that practically the rays falling on it were parallel rays. Simultaneously, and with the proper precautions, a piece of platinum paper was exposed in a Spurge sensitometer, which I have described in a paper read before the Society last year. The papers were developed together and washed and dried, the paper having been previously marked off in $\frac{1}{4}$ inches, that all error due to shrinkage might be avoided. The sensitometer print was measured for blackness, and a curve constructed; the abscissæ used were the known intensities of light, and the ordinates the blackness, or perhaps I should say the amount of whiteness left. This was measured with my photometer in the way I have described here and in other papers. The wedge print was measured in the same way at every $\frac{1}{4}$ of an inch, and the intensities of light acting at every $\frac{1}{4}$ inch derived from the curve, the amount of whiteness indicating the intensity which had acted.

The measurements gave me the coefficient of absorption. This gave a star magnitude of 1·38 per inch.

Now evidently the value thus obtained would not be the same as the value to the eye, since it is the yellow part of the spectrum which has most effect on the latter and the

blue on the former. To obtain this value a solution of chromate of potash was placed in front of the light, and a Carbutt
film of bromide of silver placed in contact with the wedge,
a sensitometer containing the same sensitive surface being
exposed simultaneously to the same light. This light gave the
maximum photographic sensitiveness in the yellow-green, and
accorded very well with that of the eye. The densities of the
sensitometer negative and of the wedge negative were measured
as before, and in this case the star magnitude per inch came out
1·20 to 1·21. Another experiment gave the value of 1·21 to 1·22,
whilst a third gave the value 1 20 to 1 22. We may take it that
the value does not much differ from 1·21. To determine the
coefficient in red light, the wedge and sensitometer were exposed
to light passing through what is known as stained red glass. It
is a glass preferable to ruby glass, as this last allows a small
percentage of blue rays to pass. Proceeding as before in
measuring the negatives, in two experiments the values ·96 and ·93,
or a mean of ·945, were obtained. It was only after the second set
of experiments with the light passing through the chromate cell
that I communicated with Dr. Spitta. He then informed me that
his coefficients per inch gave him the following figures in star
magnitudes :—

By method of reflection from mirrors   ...   ...   1·192

By rotating photometer   ...   .   1·176

By polarising method with diaphragm   ...   ...   1·160

By   „   „   without diaphragm ...   ...   1·42

The only result of mine comparable with these is that obtained with light passing through the chromate solution, which
gave me 1·21, a value a little higher than his value, 1·192.

I think this small discrepancy can be accounted for, if we
take into consideration that he used gaslight—a light which
contains a greater proportion of red and yellow than does sunlight; for, as has been stated, the red light is more absorbed
than the yellow by this particular wedge. This being so, the
maximum optical effect would be obtained in a part of the spectrum slightly nearer to the red than he would have obtained
with sunlight.

The light I used was the electric light; and I have shown
that the light from the positive pole of the electric light is very
nearly the same as that of sunlight at noon about the middle of
May. The results obtained with the electric light would therefore be very closely the same as that obtained with sunlight
or with certain classes of stars.

The experiments I have carried out seem to point to this
wedge having a different coefficient for different classes of stars.
The difference should be most observable in red stars.

In conclusion, I may say that as well as films I tried glass

plates backed with a black material to avoid halation. I was not satisfied that halation would not throw out the accuracy of results somewhat. The experiments showed that my fears were groundless.

I think it satisfactory, at all events, for the photographic method of scaling, that Dr. Spitta's and my own coefficients come out so close as they do. The wedge seems to be very uniform in its coefficient of absorption throughout, as the results at the darker end were the same as those of the lighter.

Note on some Variable Stars near the Cluster 5 M.
By A. A. Common, F.R.S.

On comparing some photographs of the Cluster 5 Messier lately taken with the five-foot telescope, I was surprised to find that on one plate there were stars that were quite invisible on the other plates. Considerable variation in the size of the impressions of the stars on the plate is not at all unusual, but the appearance of new stars of considerable magnitude on one plate, without a trace of them on plates taken before and after, is worthy of notice. Four photographs of this Cluster have been taken this year—on April 22, May 9, May 15, and June 9, with 25, 45, 66, and 45 minutes' exposure respectively.

The plate taken on May 15, with the longest exposure, contains five stars not shown on the other plates; the position with regard to the centre of the Cluster is given below :—

No.	Mag.	R	δ
1	9·5	20 p	19′ N
2	10·0	10 f	1·5 N
3	9·5	40 f	12 S
4	10·0	56 f	20 S
5	9·0	66 f	10·5 N

The magnitude of the above stars is estimated from the 9·5 (Argelander) star about 18′ south of the Cluster.

The plate on which these stars appear has more stars than the other three plates, owing to the longer exposure, but stars of at least the 12th magnitude are shown on all of them; so that the presence of the new stars is not due to the longer exposure. On re-measuring the plates, to check the position of the five stars, I find that there is a great difference in the apparent magnitude of many of the stars near the Cluster, particularly with one star of about 10· magnitude, about 3ˢ f the centre of Cluster: on the 1st, 3rd, and 4th plates it is an unmistakable object; on the 2nd plate, taken May 9, it is there, but just the same magnitude as the other stars of the Cluster—possibly two magnitudes less than its magnitude on the other plates.

On the Variable Star U (" Nova") Orionis.   By J. E. Gore.

From a reduction of all my observations of this variable star since the date of its discovery, 1885 December 13, I find the following epochs of maxima:—

1885 Dec. 13?	1889 Jan. 1
1886 „ 11	1890 „ 13
1887 „ 30	

Treating these by the method of least squares, I find the following elements:—

Maximum = 1887, Dec. 26·4 + 373^d·6 E.

As, however, it seems probable that the star had passed the maximum previous to the night of its discovery, I have thought it safer to neglect this maximum, and deduce elements from the following observation of maxima:—

1886 Dec. 11	Gore	1889 Jan. 1	Gore
„ 13	Sawyer	1890 Jan. 3	Yendell
1887 Dec. 30	Gore	„ 6	Sawyer
1888 Dec. 26	Sawyer	„ 13	Gore
„ 27·5	Yendell		

Treating these by the method of least squares, I find the following provisional elements ·—

Maximum = 1887, Dec. 22·36 + 373·47 E.

The following is a comparison between the observed maxima and those computed from the above elements:—

Observed Maxima.	Computed Maxima.	O−C. days.
1885 Dec. 13	1885 Dec. 5·42	+ 7·59
1886 Dec. 11	1886 Dec. 13·89	− 2·89
„ 13	„ 13·89	− 0·89
1887 Dec. 30	1887 Dec. 22·36	+ 7·64
1888 Dec. 26	1888 Dec. 29·83	− 3·83
„ 27·5	„ 29·83	− 2·33
1889 Jan. 1	„ 29·83	+ 2·17
1890 Jan. 3	1890 Jan. 7·3	− 4·3
„ 6	„ 7·3	− 1·3
„ 13	„ 7·3	+ 5·7

These elements give the date of the next maximum 1891, January 15·77.

On the Proper Motions of Three Stars.   By W. T. Lynn, B.A.

In vols. xxxi. and xxxiii. of the *Monthly Notices* I gave the proper motions, by the aid of a few then recent Greenwich observations, of three stars which had been found to have large motions. But as all three are contained in the new 10-year catalogue, it is now possible to deduce tolerably accurate values of the proper motions from Greenwich observations (all made with the same instrument and directly comparable) only. This I here proceed to do, and beg to offer the results to the Society, taking the stars in the order of right ascension.

1. The first is Lalande 21185 = W. B. (2) X. 1112. In my paper in the *Monthly Notices* for November 1872 (vol. xxxiii. p. 52), I gave the (corrected) values deducible from the places used in the two 7-year catalogues, the first of which was in both elements, the second in N.P.D. (in which element the proper motion is large) only. Adding to these the places given in the 9-year and the 10-year catalogues we obtain :—

Epoch.	R.A.	No. of Obs.	N.P.D.	No. of Obs.	Authority.
	h m s		° ′ ″		
1860	10 55 40·56	2	53 5 34·86	2	7-year Cat. (1860)
1864	...	0	53 7 9·24	2	7-year Cat. (1864)
1872	10 56 20·17	4	53 10 21·90	4	9-year Cat.
1880	10 56 46·49	5	53 13 34·61	5	10-year Cat.

The precession for 1860 is $+3^s\cdot349$ (diminishing to $+3^s\cdot344$ in 1880) in R.A. and $+19''\cdot27$ (increasing to $+19''\cdot30$) in N.P.D. From this it would seem that, as the amount of apparent change from 1860 to 1872 is $+39^s\cdot61$ or $+3^s\cdot301$ per annum in R.A., and $+4'\cdot47''\cdot04$ or $+23''\cdot92$ per annum in N.P.D., the proper motion deducible from a comparison between the first 7-year and the 9-year catalogues is $-0^s\cdot046$ in R.A. and $+4''\cdot64$ in N.P.D. Comparing the places in the first 7-year and in the 10-year catalogues (separated by an interval of 20 years) we obtain similarly a proper motion of $-0^s\cdot049$ in R.A. and $+4'''\cdot70$ in N.P.D.

2. The second of these stars is Lalande 21258 = W. B. (2) X. 1174, of which I gave the place (corrected) from the second 7-year catalogue in the *Monthly Notices* for December 1872 (vol. xxxiii. p. 102). Tabulating this together with the places in the 9-year and the 10-year catalogues, we obtain :—

Epoch.	R A.	No. of Obs.	N.P.D.	No. of Obs.	Authority.
	h m s		° ′ ″		
1864	10 58 42·55	1	45 46 33·67	1·	7-year Cat. (1864)
1872	10 59 6·74	3	45 48 58·33	3	9-year Cat.
1880	10 59 30·54	7	45 51 26·19	6	10-year Cat.

Apparent Mean Annual Variations.

Years.	Ann. Var. in R.A.	Ann. Var. in N.P.D.
1864–1872	$+3 \cdot 024$	$+18 \cdot 08$
1872–1880	$+2 \cdot 975$	$+18 \cdot 48$

Now, as the annual precession is, for the mean epoch, $+3^{s} \cdot 413$ in R.A. and $+19'' \cdot 35$ in N.P.D., we have, for the mean proper motions from the two comparisons, $-0^{s} \cdot 413$ in R.A. and $-1'' \cdot 07$ in N.P.D.

3. The third and last of these stars is Oeltzen's Argelander 17415–6, of which I gave a provisional determination of the proper motion in the *Monthly Notices* for December 1870 (vol. xxxi. p. 42). It was not, as it happened, included in any great Greenwich catalogue until the 9-year; I can therefore now only compute its proper motion from Greenwich observations by comparing the places in that catalogue and in the recent 10-year. The former (where it is No. 1619) is R.A. $17^{h} 37^{m} 10^{s} \cdot 302$, N.P.D. $21° 32' 38'' \cdot 94$; number of observations, four in each element; epoch 1872. The latter (where it is No. 2786) is R.A. $17^{h} 37^{m} 7^{s} \cdot 400$, N.P.D. $21° 33' 4'' \cdot 15$; number of observations, four in each element; epoch 1880. This gives apparent annual variation $-0^{s} \cdot 363$ in R.A. and $+3'' \cdot 15$ in N.P.D.; and as the precession for the mean epoch is $-0^{s} 297$ in R.A. and $+2'' \cdot 00$ in N.P.D., we have, finally, for the deduced values of the proper motion in R.A. and N.P.D. respectively, $-0^{s} \cdot 066$ and $+1'' \cdot 15$.

Blackheath:
  1890 April 23.

On a coming Conjunction of a Remarkable Dark Spot on Jupiter with the Red Spot, and the relative Altitudes of these Objects. By A. Stanley Williams.

It is now twelve years since the great Red Spot made its appearance upon *Jupiter*, or at least since it first attracted general attention, and notwithstanding all the consideration that has been bestowed upon it during these twelve years, it still remains almost as much of an enigma as at its first appearance. Especially nothing is yet known for certain with regard to the altitude of the spot in the atmosphere of the planet, or with reference to neighbouring markings. A number of observations, it is true, have been made bearing upon this subject, but they are none of them decisive. Indeed, they differ curiously from each other. The object of this note is to call attention to an *unrivalled and unique opportunity* of obtaining conclusive evidence upon this important question, which is now on the point of occurring.

It is well known that most of the spots and markings of *Jupiter* situated to the south of the great equatorial system of

belts have a slow motion from east to west relative to the Red Spot.   A remarkable dark spot is now visible on the south side of the South Equatorial Belt, which by virtue of this westerly motion or drift must in a short time overtake that marking, provided, of course, that the conditions continue to remain unchanged.   The spot in question is a large, dark, very prominent and very striking feature, and is marked *a* in the accompanying figure, which represents the equatorial region of *Jupiter* as it
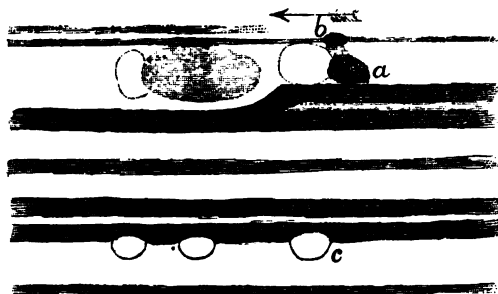
appeared about the end of May.   It is evident that, if the spot continues to sweep onwards from east to west, in the direction of the arrow, it must eventually overtake and pass the Red Spot. In that case it must, if situate at a higher level, cover about half the breadth of the latter marking.   If, on the other hand, it should lie at a lower level in the atmosphere of the planet, then the spot should disappear altogether from view.   If at about the same level it would probably be diverted.

Since the year 1879 I have observed *Jupiter* and the Red Spot more or less continuously, and in all that time have seen no other spot of such a striking and conspicuous character and so magnificently suited to solve the vexed question of the altitude of the latter marking compared with neighbouring objects.   I therefore venture to call the attention of observers to the importance of taking advantage of this *unrivalled opportunity,* which may never occur again.   It should be mentioned that the dark spot *a* was first observed as long ago as the commencement of June in last year, and has consequently already been visible for more than twelve months.   It still retains almost the same appearance which it possessed when first seen, and there is therefore every prospect of its continuing visible as a prominent object for a considerable time longer.   The following are the approximate dates on which the dark spot *a* should be in conjunction with different parts of the Red Spot :—

With the following end	...	...	29 July	1890
With the centre	...	...	...	28 Aug.	1890
With the preceding end	...	...	27 Sept.	1890

R R

From this it will be seen that the dark spot will take about two months to traverse the length of the Red Spot. It should be closely watched during all this time, but the chief interest obviously attaches to its first encounter with the following end of the latter. This will occur about the date of opposition, when *Jupiter* will be fairly well placed for observation, though his great south declination renders it very desirable that observations should be secured in more southern latitudes. The following are the observed times of transit of the dark spot over the central meridian of the planet's disc which have been obtained in the present year, with the intervals by which it followed Mr. Marth's zero meridian. They show clearly the westerly drift of the spot :—*

Date.	G.M.T. of Transit.	Following zero Meridian by.
	h m	h m
1890 Mar. 28	17 20	1 56·6
May 1	15 5·2	1 33·6
20	15 31·6	1 19·3
30	13 32	1 4·3

Besides the above-mentioned dark spot *a*, there is a little dark spot above it marked *b*. This is also worthy of notice, since in its passage westward it will just skirt the southern edge of the Red Spot, and may perhaps overlap it. Another noteworthy object is the white spot marked *c* in the figure, on the north edge of the North Equatorial Belt. This is remarkable chiefly for its long-continued visibility, since it was first seen as long ago as January 27, 1885, by Mr. Denning at Bristol,† and March 19, 1885, by Dr. Terby at Louvain.‡   It has been observed at every opposition since.

Percy Lodge, Burgess Hill :
    1890 *June* 4.

* The centre of the red spot precedes this zero meridian at the present time by about 14 minutes.

† *Observatory*, 1885, p. 304.

‡ *Études sur l'aspect physique de la Planète Jupiter.* Deuxième Partie : pp. 35–37. The spot is designated Σ by Dr. Terby.

Observations of Comet a 1890 (Brooks) made at the Royal Observatory, Greenwich.

(Communicated by the Astronomer Royal.)

The observations were made with the East or Sheepshanks Equatorial, aperture 6·7 inches, by taking transits over two cross-wires at right angles to each other, and each inclined 45° to the parallel of declination.

Comet a 1890 (Brooks).

Greenwich Mean Solar Time	Observer	≮−* R.A.	Corr. for Refraction	≮−* N.P.D.	Corr. for Refraction	No. of Comp.	Apparent R.A.	Log. factor of Parallax	Apparent N.P.D.	Log. factor of Parallax	Comp. Star
d h m s		m s	s	′ ″			h m s		° ′ ″		
May 15 9 48 5	L.	−0 39·0	0·0	−10 57·3	−0·9	4	...	9·6751	...	0·7964	a
10 0 47	,,	−0 42·1	0·0	−1 37	−0·1	8	...	9·6814	...	0·7823	b
10 11 50	,,	+1 37·0	0·0	+1 38·5	+0·1	3	20 35 42·0	9·6870	47 34 49·4	0·7700	c
10 21 58	,,	−0 11·0	0·0	−7 2·2	−0·6	2	...	9·6911	...	0·7581	d
17 9 36 40	A.D.	+0 10·3	0·0	+6 18·7	+0·4	3	...	9·6901	...	0·7860	e
9 46 14	,,	−0 36·0	0·0	+6 27·6	+0·4	3	...	9·6956	...	0·7748	f
9 53 21	,,	−0 13·0	0·0	−6 42·6	−0·4	2	...	9·6992	...	0·7563	g
18 12 47 56	T.	+1 41·9	0·0	−6 20·3	−0·1	6	20 26 53·1	9·6475	44 32 45·6	0·4415	h
12 50 58	,,	+1 23·2	0·0	−5 19·3	−0·1	5	20 26 54·2	9·6440	44 32 52·5	0·4345	i
20 9 44 17	L.	+1 12·3	0·0	−5 18·4	−0·2	2	20 20 44·4	9·7272	42 42 37·4	0·7330	j
9 44 17	,,	+0 4·3	0·0	+0 7·1	0·0	2	...	9·7272	...	0·7330	k
21 9 35 59	H.	−1 10·7	0·0	+0 51·0	0·0	3	20 17 11·5	9·7355	41 44 9·1	0·7276	l
9 46 8	,,	+0 25·2	0·0	−0 3·4	0·0	4	20 17 10·0	9·7374	41 43 42·5	0·7119	m

Greenwich Mean Sid. Time.	Observer.	☾-* R.A.	Corr. for Refraction.	☾-* N.P.D.	Corr. for Refraction.	No. of Comp.	Apparent R.A.	Log. factor of Parallax.	Apparent N.P.D.	Log. factor of Parallax.	Comp. Star.
h m s		m s	s	′ ″	″		h m s		° ′ ″		
May 2 9 34 51	L.	+0 50·5	0·0	− 9 9·2	−0·2	2	20 13 24·1	9·7461	40 45 21·6	0·7119	n
9 34 51	,,	+0 48·3	0·0	− 4 16·9	−0·2	2	...	9·7461	...	0·7119	o
9 34 51	,,	−0 27·0	0·0	− 0 14·5	0·0	2	...	9·7461	...	0·7119	p
9 34 51	,,	−0 44·5	0·0	− 0 43·9	0·0	2	...	9·7461	...	0·7119	q
9 48 14	,,	−0 12·5	0·0	+ 6 11·7	+0·2	2	...	9·7492	...	0·6924	r
27 9 37 25	A.D.	+0 0·3	0·0	+ 2 23·2	+0·1	3	...	9·7969	...	0·5908	s
9 46 17	,,	−0 31·2	0·0	− 2 13·5	−0·1	3	...	9·7960	...	0·5716	t
9 55 41	,,	−1 14·2	0·0	− 4 19·9	−0·1	3	19 50 28·2	9·7944	35 55 38·0	0·5499	u
29 10 13 34	H.	−0 31·9	0·0	− 2 45·0	0·0	2	19 38 55·1	9·7996	34 4 35·9	0·4164	v
10 16 33	,,	+0 41·3	0·0	+ 5 21·1	+0·1	1	19 38 54·0	9·7980	34 4 24·9	0·4068	w
30 10 13 34	T.	−1 26·8	0·0	− 3 6·5	−0·1	3	...	9·8044	...	0·3647	x
10 14 45	,,	−1 1·3	0·0	− 4 30·8	−0·1	8	19 32 44·9	9·8032	33 11 3·1	0·3586	y
10 16 45	,,	−0 56·5	0·0	+ 1 58·9	0·0	2	...	9·8023	...	0·3529	z
31 10 1 56	A.D.	+2 25·5	0·0	+ 7 53·4	+0·2	3	19 26 15·0	9·8154	32 19 45·2	0·3438	α
10 1 56	,,	−0 6·5	0·0	+ 8 46·3	+0·2	3	...	9·8154	...	0·3468	β
10 14 19	,,	−1 31·0	0·0	+ 3 11·9	+0·1	3	...	9·8072	...	0·2998	γ
June 6 10 11 0	H.	+3 25·5	0·0	− 8 42·6	−0·2	4	18 38 43·0	9·7873	27 48 8·8	9·3230	δ
10 12 27	,,	+2 53·3	0·0	− 5 38·4	−0·1	4	18 38 42·9	9·7840	27 48 5·2	9·3029	•

Assumed Mean Places of Comparison Stars.

	Star's Name.	R.A. 1890·0.	N.P.D. 1890·0.	Authority.
		h m s	° ′ ″	
a	B.D.+42°, No. 3820	20 36 17	47 46	Bonn Observations, vol. v.
b	B.D.+42°, No. 3821	20 36 20	47 37	„ „ „
c	W.B. (2) XX. 1132	20 34 40·41	47 32 54·2	Weisse's Bessel (2).
d	B.D.+42°, No. 3815	20 35 44	47 42	Bonn Observations, vol. v.
e	B.D.+44°, No. 3506	20 30 8	45 35	„ „
g	B.D.+44°, No. 3510	20 30 52	45 33	„ „
	B.D.+44°, No. 3509	20 30 49	45 45	„ „
h	Radcliffe, 4811	20 25 10·47	44 38 49·7	Radcliffe
i	Radcliffe, 4816	20 25 30·25	44 37 55·5	„
j	B.D.+47°, No. 3091	20 19 31·19	42 47 39·8	Bonn Observations, vol. vi.
k	B.D.+47°, No. 3095	20 20 39	42 36	„ „ vol. v.
l	Oeltz. Arg. (N) 20427-8	20 18 21·25	41 43 2·1	Oeltz. Arg. (N).
m	Oeltz. Arg. (N) 20397	20 16 43·82	41 43 29·9	„ „
n	Oeltz. Arg. (N) 20296-7	20 12 32·57	40 54 15·3	„ „
o	B.D.+49°, No. 3237	20 12 36	40 49	Bonn Observations, vol. v.
p	Anonymous			
q	B.D.+49°, No. 3246	20 14 6	40 46	Bonn Observations, vol. v.

	Star's Name.	R.A. 1800·0.	N.P.D. 1800·0.	Authority.
		h m s	° ′ ″	
r	B.D.+49°, No. 3243	20 13 36	40 39	Bonn Observations, vol. v.
s	R.D.+54°, No. 2241	19 50 20	35 53	„ „
t	B.D.+53°, No. 2313	19 50 51	35 57	„ „
u	Oeltz. Arg. (N) 19786	19 51 40·90	35 59 43·6	Oeltz. Arg. (N).
v	Oeltz. Arg. (N) 19566	19 39 25·21	34 7 7·4	„
w	Oeltz. Arg. (N) 19542	19 38 12·70	33 58 50·2	„
x	Anonymous			
y	Oeltz. Arg. (N) 19459	19 33 44·29	33 15 21·0	Oeltz. Arg. (N).
z	B.D.+56°, No. 2270	19 33 43	33 10	Bonn Observations, vol. v.
a	Groombridge, 2852	19 23 47·46	32 11 39·3	Radcliffe.
β	B.D.+57°, No. 2008	19 26 19	32 10	Bonn Observations, vol. v.
γ	B.D.+57°, No. 2013	19 27 40	32 16	„
δ	Oeltz. Arg. (N) 18486	18 35 14·90	27 56 43·8	Oeltz. Arg. (N).
ε	Oeltz. Arg. (N) 18495	18 35 46·90	27 53 35·8	„

Notes.

May 15. Comet very bright.   May 18. Comet very faint.   May 30. Comet rather faint.

The observations are corrected for refraction, but not for parallax.

The initials A.D., T., L., and H. are those of Mr. Downing, Mr. Thackeray, Mr. Lewis, and Mr. Hollis respectively.

Observations of Comet a 1890 (Brooks) made at the Royal Observatory, Greenwich.

(Communicated by the Astronomer Royal.)

The observations were made with the East or Sheepshanks Equatorial, aperture 6·7 inches, by taking transits over two cross-wires at right angles to each other, and each inclined 45° to the parallel of declination. Power 60.

Comet a 1890 (Brooks).

Greenwich Mean Solar Time.	Observer.	☄−* R.A.	Corr. for Refraction.	☄−* N.P.D.	Corr. for Refraction.	No. of Comp.	Apparent R.A.	Log. factor of Parallax.	Apparent N.P.D.	Log. factor of Parallax.	Comp. Star.
d h m s		m s	s	′ ″	″		h m s		° ′ ″		
June 26 10 6 55·2	H.	+2 5·5	0·0	+ 2 53·1	0·0	4	15 14 13·7	9·4116	26 14 7·5	0·2121n	a
10 18 54·5	,,	−1 13·8	0·0	−12 22·2	−0·2	2	15 14 11·9	9·4790	26 14 17·0	0·1955n	b
10 18 54·5	,,	−2 46·4	0·0	−12 23·1	−0·2	2	15 14 12·1	9·4790	26 14 15·6	0·1955n	c
27 10 25 17·6	T.	+0 14·4	0·0	+ 2 18·8	0·0	5	...	9·5532	...	0·1298n	d
10 25 17·6	,,	+0 30·4	0·0	+ 2 5·3	0·0	5	...	9·5532	...	0·1298n	e
30 10 21 37·6	H.	−0 17·8	0·0	+ 3 32·2	0·0	6	14 44 48·3	9·6259	28 2 3·7	9·9026n	f
10 36 48·4	,,	+5 23·3	0·0	−13 46·4	−0·2	2	14 44 43·7	9·6704	28 2 9·8	9·8195n	g
Aug. 4 10 13 13·6	H.	−1 21·4	0·0	− 1 8·0	0·0	4	...	9·7105	...	0·6923	h
10 21 9·0	,,	−0 57·2	0·0	+ 7 11·4	+0·2	2	...	9·7100	...	0·7038	i
10 29 4·3	,,	−3 25·0	0·0	+ 2 45·0	+0·1	2	13 8 23·8	9·7095	45 37 17·5	0·7153	j
15 10 25 41·0	T.	+1 35·2	0·0	− 3 31·8	−0·3	3	...	9·6677	...	0·7926	k
10 28 24·1	,,	−0 37·9	0·0	− 3 13·5	−0·2	5	13 2 39·1	9·6662	49 37 25·9	0·7954	l
10 32 28·6	,,	−0 57·3	0·0	+ 4 20·4	+0·3	2	...	9·6641	...	0·7995	m

Assumed Mean Places of Comparison Stars.

	Star's Name.	R.A. 1890·0.	N.P.D. 1890·0.	Authority.
a	B.D.+63°, No. 1178	15 12 5·91	26 11 25·5	Bonn Observations, vol. vi.
b	Oeltz. Arg. (N), 15292	15 15 23·21	26 26 50·4	Oeltz. Arg. (N).
c	Oeltz. Arg. (N), 15312	15 16 56·07	26 26 49·8	„ „
d	B.D.+63°, No. 1168	15 5 51	26 37	Bonn Observations, vol. v.
e	B.D.+63°, No. 1170	15 6 39	26 38	„ „
f	B.D.+62°, No. 1368	14 45 4·15	27 58 44·2	„ „ vol. vi.
g	Groombridge, 2146	14 39 18·63	28 16 9·1	Greenwich Ten-Year Catalogue.
h	B.D.+44°, No. 2257	13 9 41	45 39	Bonn Observations, vol. v.
i	B.D.+44°, No. 2256	13 9 18	45 31	„ „
j	B.D.+44°, No. 2264	13 11 48·58	45 34 43·3	„ „ vol. vi.
k	B.D.+40°, No. 2622	13 0 57	49 40	„ „ vol. iv.
l	W.B. (2) XIII. 4	13 3 18·00	49 40 48·4	Weisse's Bessel (2).
m	Anonymous			

The observations are corrected for refraction, but not for parallax.
The initials T. and H. are those of Mr. Thackeray and Mr. Hollis respectively.

Two Auxiliary Tables for the Solution of Kepler's Problem.
By A. Marth.

If e denotes the eccentricity, ϵ and μ the eccentric and mean anomaly, the multiplication of Kepler's equation

$$\epsilon - \mu = e \sin \epsilon \text{ by } \frac{\sin(\epsilon-\mu)}{\epsilon-\mu}$$

gives the equivalent equation

$$\tan \epsilon = \frac{\sin \mu}{\cos \mu - e \cdot \dfrac{\sin(\epsilon-\mu)}{\epsilon-\mu}}.$$

But

$$\frac{\sin(\epsilon-\mu)}{\epsilon-\mu} = \frac{\sin(e\sin\epsilon)}{e\sin\epsilon}$$

$$= 1 - \frac{e^2\sin^2\epsilon}{6} + \frac{e^4\sin^4\epsilon}{120} - \frac{e^6\sin^6\epsilon}{5040} + \frac{e^8\sin^8\epsilon}{362880} - \frac{e^{10}\sin^{10}\epsilon}{39916800} + \cdots$$

$$= 1 - e^2\sin^2\epsilon \cdot \nu$$

if

$$\nu = \frac{1}{6}\left(1 - \frac{e^2\sin^2\epsilon}{20} + \frac{e^4\sin^4\epsilon}{840} - \frac{e^6\sin^6\epsilon}{60480} + \frac{e^8\sin^8\epsilon}{6652800} - \cdots\right)$$

Hence

$$\tan \epsilon = \frac{\sin \mu}{\cos \mu - e + e^2 \cdot \sin^2\epsilon \cdot \nu}.$$

This is the formula which I considered the most suitable for finding $\tan \epsilon$, and which would have appeared in the paper published on p. 511 of the last number of the *Monthly Notices*, accompanied by the first of the following tables, had not some doubts, which I may be allowed to explain, induced me to make some alterations in the proof-sheet and to defer the publication of the table.

Not having had, or having missed, the opportunity of seeing Oppolzer's table in vol. 50 of the *Denkschriften* of the Vienna Academy till shortly before the last meeting of the Royal Astronomical Society, I was surprised to find that his table, giving the values of

$$\log \frac{E-M}{\sin(E-M)} \text{ or } \log \lambda$$

for solving Kepler's equation in the form

$$tg\,(E-M) = \frac{e \sin M}{\lambda - e \cos M},$$

fills not less than 55 quarto pages, though it does not extend beyond $\log \tan (E - M) = 9\cdot800$ or $E - M = 32° 15'$, which is, indeed, sufficient for the orbits of the minor planets, but leaves considerable portions of the orbits of the periodical comets unprovided for. I should have expected that Oppolzer would have preferred a table of a few pages only, furnishing

$$\log \frac{\lambda - 1}{tg^2 (E - M)}$$

or (say) $\log f$ for solving the equation in the form

$$tg (E - M) = \frac{e \sin M}{(1 - \cos M) + tg^2 (E - M) \cdot f},$$

the application of which in the second and succeeding approximations would not give more trouble than that of the adopted form.

However, as my own preference might be only an individual one, and as the question of advantages and disadvantages could not well be settled without a number of numerical applications, for which, in the absence of the second of the following tables, there was no time, I deferred my decision which table to give, and made the alteration in the proof-sheet, which, however desirous not to prejudge the question, I need not have made.

I now give two tables, the second (p. 537) containing the values of $\log \dfrac{e \sin \epsilon}{\sin (e \sin \epsilon)}$ or (adopting Oppolzer's letter λ instead of the ν on p. 151) $\log \lambda$ for finding $\tan \epsilon$ by means of the equation

$$\tan \epsilon = \frac{\sin \mu}{\cos \mu - \dfrac{e}{\lambda}} = \frac{\lambda \sin \mu}{\lambda \cos \mu - e},$$

while the first table (p. 532) supplies the values of $\log \nu$ (as defined before) for finding ϵ either by means of the equation

$$\tan \epsilon = \frac{\sin \mu}{(\cos \mu - e) + e^2 \cdot \sin^2 \epsilon \cdot \nu},$$

or, if preferred, by means of the equations

$$\gamma \sin \epsilon_1 = \sin \mu$$
$$\gamma \cos \epsilon_1 = \cos \mu - e$$
$$\sin (\epsilon - \epsilon_1) = -\frac{e^2}{\gamma} \cdot \sin^2 \epsilon \cdot \nu.$$

The first table is applicable for all eccentricities, for which the eccentric anomaly is employed. The second table is not given beyond the argument

$$\log (e \sin \epsilon) = 9\cdot880, \text{ or } \epsilon - \mu = 43°\cdot46.$$

The logarithms of ν and λ have been computed by means of the series

$$\log \nu = \log \tfrac{1}{6} - \frac{m}{20} \cdot e^2 \sin^2\epsilon - \frac{m}{16800} \cdot e^4 \sin^4\epsilon \quad \text{(m modulus)}$$

$$+ \frac{m}{756000} \cdot e^6 \sin^6\epsilon + \frac{89\,m}{3104640000} e^8 \sin^8\epsilon + \ldots$$

$$\log \lambda = \frac{m}{6} \cdot e^2 \sin^2\epsilon + \frac{m}{180} \cdot e^4 \sin^4\epsilon + \frac{m}{2835} \cdot e^6 \sin^6\epsilon + \frac{m}{37800} \cdot e^8 \sin^8\epsilon$$

$$+ \frac{m}{467775} e^{10} \sin^{10}\epsilon + \frac{691\,m}{3831077250} \cdot e^{12} \sin^{12}\epsilon + \ldots$$

Table I.: log ν.

$$\tan \epsilon = \frac{\sin \mu}{(\cos \mu - e) + e^2 \cdot \sin^2\epsilon \cdot \nu} \quad \text{or}$$

$$\gamma \sin \epsilon_1 = \sin \mu$$
$$\gamma \cos \epsilon_1 = \cos \mu - e$$
$$\sin (\epsilon - \epsilon_1) = -\frac{e^2}{\gamma} \cdot \sin^2\epsilon \cdot \nu$$

log (e sin ε)	log ν		log (e sin ε)	log ν		log (e sin ε)	log ν	
9·00	9·221 632	11	9·20	9·221 303	25	9·400	9·220 4785	126
·01	621	10	·21	278	27	·402	4659	128
·02	611	12	·22	251	29	·404	4531	130
·03	599	11	·23 ·	222	29	·406	4401	130
·04	588	13	·24	193	31	·408	4271	131
·05	9·221 575	13	·25	9·221 162	32	9·410	9·220 4140	133
·06	562	13	·26	130	34	·412	4007	134
·07	549	14	·27	096	36	·414	3873	135
·08	535	15	·28	060	37	·416	3738	137
·09	520	15	·29	9·221 023	39	·418	3601	138
9·10	9·221 505	17	9·30	9·220 984	41	9·420	9·220 3463	139
·11	488	17	·31	943	42	·422	3324	140
·12	471	17	·32	901	45	·424	3184	142
·13	454	19	·33	856	47	·426	3042	143
·14	435	20	·34	809	49	·428	2899	144
·15	9·221 415	20	·35	·9·220 760	51	9·430	9·220 2755	145
·16	395	21	·36	709	54	·432	2610	147
·17	374	23	·37	655	56	·434	2463	149
·18	351	23	·38	599	59	·436	2314	149
·19	328	25	·39	540	61	·438	2165	151
9·20	9·221 303		9·40	9·220 479		9·440	9·220 2014	

log (e sin e)	log ν		log (e sin e)	log ν		log (e sin e)	log ν	
9·440	9·220 2014	153	9·520	9·219 4675	221	9·600	9·218 4066	159
·442	1861	154	·522	4454	222	·601	3907	160
·444	1707	155	·524	4232	225	·602	3747	160
·446	1552	157	·526	4007	226	·603	3587	161
·448	1395	158	·528	3781	229	·604	3426	162
9·450	9·220 1237	159	9·530	9·219 3552	230	·605	9·218 3264	163
·452	1078	161	·532	3322	233	·606	3101	163
·454	0917	163	·534	3089	235	·607	2938	164
·458	0754	164	·536	2854	238	·608	2774	165
·458	0590	166	·538	2616	239	·609	2609	166
9·460	9·220 0424	167	9·540	9·219 2377	242	9·610	9·218 2443	167
·462	·220 0257	169	·542	2135	244	·611	2276	167
·464	·220 0088	170	·544	1891	246	·612	2109	168
·466	·219 9918	172	·546	1645	248	·613	1941	168
·468	·219 9746	173	·548	1397	251	·614	1773	170
9·470	9·219 9573	175	9·550	9·219 1146	253	·615	9·218 1603	170
·472	9398	177	·552	0893	255	·616	1433	171
·474	9221	178	·554	0638	258	·617	1262	172
·476	9043	180	·556	0380	260	·618	1090	173
·478	8863	182	·558	9·219 0120	263	·619	0917	173
9·480	9·219 8681	183	9·560	9·218 9857	265	9·620	9·218 0744	174
·482	8498	185	·562	9592	267	·621	0570	175
·484	8313	187	·564	9325	270	·622	0395	176
·486	8126	188	·566	9055	272	·623	0219	177
·488	7938	190	·568	8783	275	·624	9·218 0042	178
9·490	9·219 7748	192	9·570	9·218 8508	278	·625	9·217 9864	178
·492	7556	194	·572	8230	280	·626	9686	179
·494	7362	195	·574	7950	282	·627	9507	180
·496	7167	198	·576	7668	285	·628	9327	181
·498	6969	199	·578	7383	288	·629	9146	181
9·500	9·219 6770	201	9·580	9·218 7095	291	9·630	9·217 8965	183
·502	6569	203	·582	6804	293	·631	8782	183
·504	6366	204	·584	6511	296	·632	8599	184
·506	6162	207	·586	6215	299	·633	8415	185
·508	5955	208	·588	5916	301	·634	8230	186
9·510	9·219 5747	211	8·590	9·218 5615	304	·635	9·217 8044	187
·512	5536	212	·592	5311	307	·636	7857	188
·514	5324	215	·594	5004	310	·637	7669	188
·516	5109	216	·596	4694	313	·638	7481	189
·518	4893	218	·598	4381	315	·639	7292	190
9·520	9·219 4675		8·600	9·218 4066		9·640	9·217	

log (e sin e)	log ν			log (e sin e)	log ν			log (e sin e)	log ν		
9·640	9·217	7102	191	9·680	9·216	8728	229	9·720	9·215	8661	277
·641		6911	192	·681		8499	231	·721		8384	277
·642		6719	193	·682		8268	232	·722		8107	279
·643		6526	194	·683		8036	233	·723		7828	280
·644		6332	195	·684		7803	234	·724		7548	281
·645	9·217	6137	195	·685	9·216	7569	235	·725	9·215	7267	283
·646		5942	197	·686		7334	236	·726		6984	284
·647		5745	197	·687		7098	237	·727		6700	285
·648		5548	198	·688		6861	239	·728		6415	287
·649		5350	199	·689		6622	239	·729		6128	288
9·650	9·217	5151	200	9·690	9·216	6383	241	9·730	9·215	5840	289
·651		4951	201	·691		6142	242	·731		5551	291
·852		4750	202	·692		5900	242	·732		5260	292
·653		4548	203	·693		5658	244	·733		4968	293
·654		4345	204	·694		5414	245	·734		4675	295
·655	9·217	4141	205	·695	9·216	5169	246	·735	9·215	4380	297
·656		3936	205	·696		4923	248	·736		4083	297
·657		3731	207	·697		4675	248	·737		3786	298
·658		3524	208	·698		4427	250	·738		3488	300
·659		3316	208	·699		4177	251	·739		3188	301
9·660	9·217	3108	210	9·700	9·216	3926	252	9·740	9·215	2887	303
·661		2898	210	·701		3674	253	·741		2584	305
·662		2688	212	·702		3421	254	·742		2279	305
·663		2476	212	·703		3167	255	·743		1974	307
·664		2264	214	·704		2912	257	·744		1667	309
·665	9·217	2050	214	·705	9·216	2655	258	·745	9·215	1358	310
·666		1836	215	·706		2397	259	·746		1048	311
·667		1621	217	·707		2138	260	·747		0737	313
·688		1404	217	·708		1878	261	·748		0424	314
·669		1187	218	·709		1617	263	·749	9·215	0110	316
9·670	9·217	0969	220	9·710	9·216	1354	264	9·750	9·214	9794	317
·671		0749	220	·711		1090	265	·751		9477	319
·672		0529	222	·712		0825	266	·752		9158	320
·673		0307	222	·713		0559	267	·753		8838	322
·674	9·217	0085	224	·714		0292	269	·754		8516	323
·675	9·216	9861	224	·715	9·216	0023	270	·755	9·214	8193	324
·676		9637	226	·716	9·215	9753	271	·755		7869	326
·677		9411	226	·717		9482	273	·757		7543	328
·678		9185	228	·718		9209	273	·758		7215	329
·679		8957	229	·719		8936	275	·759		6886	331
9·680	9·218	8728		9·720	9·215	8661		9·760	9·214	6555	

log(e sin e)	log v		log(e sin e)	log v		log(e sin e)	log v	
9·760	9·214 6555	332	9·800	9·213 1999	399	9·840	9·211 4496	480
·761	6223	334	·801	·213 1600	402	·841	·211 4016	483
·762	5889	335	·802	·213 1198	403	·842	·211 3533	485
·763	5554	337	·803	·213 0795	405	·843	·211 3048	487
·764	5217	338	·804	·213 0390	407	·844	·211 2561	489
·765	9·214 4879	340	·805	·212 9983	408	·845	·211 2072	491
·766	4539	341	·806	·212 9575	411	·846	·211 1581	494
·767	4198	343	·807	·212 9164	412	·847	·211 1087	496
·768	3855	345	·808	·212 8752	415	·848	·211 0591	498
·769	3510	346	·809	·212 8337	416	·849	·211 0093	501
9·770	9·214 3164	348	9·810	9·212 7921	418	9·850	9·210 9592	503
·771	2816	350	·811	·212 7503	420	·851	·210 9089	505
·772	2466	351	·812	·212 7083	423	·852	·210 8584	508
·773	2115	352	·813	·212 6660	424	·853	·210 8076	510
·774	1763	354	·814	·212 6236	426	·854	·210 7666	512
·775	9·214 1409	356	·815	·212 5810	428	·855	·210 7054	515
·776	1053	358	·816	·212 5382	430	·856	·210 6539	517
·777	0695	359	·817	·212 4952	432	·857	·210 6022	519
·778	9·214 0336	361	·818	·212 4520	434	·858	·210 5503	522
·779	·213 9975	363	·819	·212 4086	435	·859	·210 4981	524
9·780	9·213 9612	364	9·820	9·212 3651	438	9·860	9·210 4457	527
·781	9248	366	·821	·212 3213	440	·861	·210 3930	529
·782	8882	368	·822	·212 2773	442	·862	·210 3401	532
·783	8514	369	·823	·212 2331	445	·863	·210 2869	534
·784	8145	371	·824	·211 1886	446	·864	·210 2335	536
·785	9·213 7774	373	·825	·212 1440	448	·865	·210 1799	539
·786	7401	374	·826	·212 0992	450	·866	·210 1260	541
·787	7027	376	·827	·212 0542	452	·867	·210 0719	544
·788	6651	378	·828	·212 0090	455	·868	·210 0175	547
·789	6273	380	·829	·211 9635	456	·869	·209 9628	549
9·790	9·213 5893	381	9·830	9·211 9179	459	9·870	9·209 9079	551
·791	5512	383	·831	·211 8720	461	·871	·209 8528	554
·792	5129	385	·832	·211 8259	463	·872	·209 7974	557
·793	4744	387	·833	·211 7796	465	·873	·209 7417	559
·794	4357	388	·834	·211 7331	467	·874	·209 6858	562
·795	9·213 3869	391	·835	·211 6864	469	·875	·209 6296	564
·796	3578	392	·836	·211 6395	472	·876	·209 5732	567
·797	3186	394	·837	·211 5923	473	·877	·209 5165	570
·798	2792	395	·838	·211 5450	476	·878	·209 4595	572
·799	2397	398	·839	·211 4974	478	·879	·209 4023	575
9·800	9·213 1999		9·840	9·211 4496		9·880	9·209 3448	

log (e sin e)	log ν		log (e sin e)	log ν		log (e sin e)	log ν	
9·880	9·209 3448	578	9·920	9·206 8137	695	9·960	9·203 7697	835
·881	·209 2870	580	·921	·206 7442	698	·961	·203 6862	840
·882	·209 2290	583	·922	·206 6744	701	·962	·203 6022	843
·883	·209 1707	586	·923	·206 6043	704	·963	·203 5179	847
·884	·209 1121	588	·924	·206 5339	707	·964	·203 4332	850
·885	·209 0533	591	·925	·206 4632	711	·965	·203 3482	855
·886	·208 9942	594	·926	·206 3921	714	·966	·203 2627	859
·887	·208 9348	596	·927	·206 3207	718	·967	·203 1868	863
·888	·208 8752	599	·928	·206 2489	720	·968	·203 0905	866
·889	·208 8153	602	·929	·206 1769	724	·969	·203 0039	871
9·890	9·208 7551	605	9·930	9·206 1045	728	9·970	9·202 9168	875
·891	·208 6946	608	·931	·206 0217	730	·971	·202 8293	879
·892	·208 6338	610	·932	·205 9587	734	·972	·202 7414	882
·893	·208 5728	613	·933	·205 8853	738	·973	·202 6532	887
·894	·208 5115	616	·934	·205 8115	741	·974	·202 5645	891
·895	·208 4499	619	·935	·205 7474	745	·975	·202 4754	895
·896	·208 3880	622	·936	·205 6629	747	·976	·202 3859	900
·897	·208 3258	625	·937	·205 5882	751	·977	·202 2959	903
·898	·208 2633	627	·938	·205 5131	755	·978	·202 2056	908
·899	·208 2006	631	·939	·205 4376	758	·979	·202 1148	912
9·900	9·208 1375	633	9·940	9·205 3618	761	9·980	9·202 0236	916
·901	·208 0742	636	·941	·205 2857	765	·981	·201 9320	920
·902	·208 0106	639	·942	·205 2092	769	·982	·201 8400	924
·903	·207 9467	643	·943	·205 1323	772	·983	·201 7476	929
·904	·207 8824	645	·944	·205 0551	776	·984	·201 6547	933
·905	·207 8179	648	·945	·204 9775	780	·985	·201 5614	938
·906	·207 7531	651	·946	·204 8995	783	·986	·201 4676	942
·907	·207 6880	654	·947	·204 8212	787	·987	·201 3734	946
·908	·207 6226	657	·948	·204 7425	790	·988	·201 2788	950
·909	·207 5569	660	·949	·204 6635	794	·989	·201 1838	955
9·910	9·207 4909	664	9·950	9·204 5841	798	9·990	9·201 0883	959
·911	·207 4245	666	·951	·204 5043	801	·991	·200 9924	964
·912	·207 3579	669	·952	·204 4242	805	·992	·200 8960	968
·913	·207 2910	673	·953	·204 3437	809	·993	·200 7992	973
·914	·207 2237	675	·954	·204 2628	812	·994	·200 7019	977
·915	·207 1562	679	·955	·204 1816	816	·995	·200 6042	982
·916	·207 0883	682	·956	·204 1000	820	·996	·200 5060	986
·917	·207 0201	685	·957	·204 0180	824	·997	·200 4074	991
·918	·206 9516	688	·958	·203 9356	828	·998	·200 3083	995
·919	·206 8828	691	·959	·203 8528	831	9·999	·200 2088	1000
9·920	9·206 8137		9·960	9·203 7697		0·000	9·200 1088	

$$\tan e = \frac{\sin \mu}{\cos \mu - \dfrac{3}{\lambda}}$$

Table II.: log λ.

log (e sin e)	log λ	diff
7·6	·000 0011	7
7·7	0018	11
7·80	·000 0029	7
7·85	0036	10
7·90	0046	11
7·95	0057	15
8·00	0072	19
8·05	0091	24
8·10	·000 0115	11
·12	0126	12
·14	0138	13
·16	0151	15
·18	0166	16
8·20	·000 0182	17
·22	0199	20
·24	0219	21
·26	0240	23
·28	0263	25
8·30	·000 0288	28
·32	0316	30
·34	0346	34
·36	0380	37
·38	0417	40
8·40	·000 0457	44
·42	0501	48
·44	0549	53
·46	0602	58
·48	0660	64
8·50	·000 0724	34
8·51	0758	36
8·52	0794	37
8·53	0831	39
8·54	0870	41
8·55	0911	43
8·56	0954	45
8·57	0999	47
8·58	1046	50
8·59	1096	51
8·60	·000 1147	

log (e sin e)	log λ	diff
8·60	·000 1147	54
8·61	1201	57
8·62	1258	59
8·63	1317	62
8·64	1379	65
8·65	·000 1444	68
8·66	1512	72
8·67	1584	74
8·68	1658	78
8·69	1736	82
8·70	·000 1818	43
	1861	43
8·71	1904	44
	1948	46
8·72	1994	46
	2040	48
8·73	2088	48
	2136	50
8·74	2186	51
	2237	52
8·75	·000 2289	53
	2342	55
8·76	2397	56
	2453	57
8·77	2510	59
	2569	59
8·78	2628	62
	2690	62
8·79	2752	64
	2816	66
8·80	·000 2882	67
	2949	69
8·81	3018	70
	3088	72
8·82	3160	74
	3234	75
8·83	3309	77
	3386	79
8·84	3465	81
	3546	82
8·85	·000 3628	

log (e sin e)	log λ	diff
8·85	·000 3628	85
	3713	86
8·86	3799	89
	3888	90
8·87	3978	93
	4071	95
8·88	4166	97
	4263	99
8·89	4362	102
	4464	104
8·900	·000 4568	42
·902	4610	43
·904	4653	43
·906	4696	43
·908	4739	44
8·910	·000 4783	45
·912	4828	44
·914	4872	45
·916	4917	46
·918	4963	46
8·920	·000 5009	46
·922	5055	47
·924	5102	47
·926	5149	48
·928	5197	48
8·930	·000 5245	48
·932	5293	49
·934	5342	50
·936	5392	50
·938	5442	50
8·940	·000 5492	51
·942	5543	51
·944	5594	52
·946	5646	52
·948	5698	53
8·950	·000 5751	53
·952	5804	54
·954	5858	54
·956	5912	55
·958	5967	55
8·960	·000 6022	

log (e sin e)	log λ		log (e sin e)	log λ		log (e sin e)	log λ	
8·960	·000 6022	56	9·040	·000 8706	80	9·120	·001 2586	116
·962	6078	56	·042	8786	82	·122	2702	118
·964	6134	57	·044	8868	82	·124	2820	119
·966	6191	57	·046	8950	83	·126	2939	120
·968	6248	58	·048	9033	83	·128	3059	120
8·970	·000 6306	58	9·050	·000 9116	85	9·130	·001 3179	122
·972	6364	59	·052	9201	85	·132	3301	124
·974	6423	60	·054	9286	86	·134	3425	124
·976	6483	60	·056	9372	87	·136	3549	125
·978	6543	60	·058	9459	87	·138	3674	127
8·980	·000 6603	61	9·060	·000 9546	88	9·140	·001 3801	128
·982	6664	62	·062	9634	90	·142	3929	129
·984	6726	62	·064	9724	90	·144	4058	130
·986	6788	63	·066	9814	90	·146	4188	131
·988	6851	64	·068	9904	92	·148	4319	133
8·990	·000 6915	64	9·070	·000 9996	93	9·150	·001 4452	134
·992	6979	64	·072	·001 0089	93	·152	4586	135
·994	7043	65	·074	0182	94	·154	4721	136
·996	7108	66	·076	0276	95	·156	4857	138
·998	7174	67	·078	0371	96	·158	4995	138
9·000	·000 7241	67	9·080	·001 0467	97	9·160	·001 5133	140
·002	7308	67	·082	0564	98	·162	5273	142
·004	7375	69	·084	0662	99	·164	5415	143
·006	7444	69	·086	0761	100	·166	5558	144
·008	7513	69	·088	0861	100	·168	5702	145
9·010	·000 7582	70	9·090	·001 0961	102	9·170	·001 5847	147
·012	7652	71	·092	1063	102	·172	5994	148
·014	7723	72	·094	1165	103	·174	6142	149
·016	7795	72	·096	1268	105	·176	6291	151
·018	7867	73	·098	1373	105	·178	6442	153
9·020	·000 7940	73	9·100	·001 1478	106	9·180	·001 6595	153
·022	8013	74	·102	1584	107	·182	6748	155
·024	8087	75	·104	1691	109	·184	6903	157
·026	8162	76	·106	1800	109	·186	7060	158
·028	8238	76	·108	1909	110	·188	7218	159
9·030	·000 8314	77	9·110	·001 2019	111	9·190	·001 7377	161
·032	8391	77	·112	2130	113	·192	7538	163
·034	8468	79	·114	2243	113	·194	7701	164
·036	8547	79	·116	2356	114	·196	7865	165
·038	8626	80	·118	2470	116	·198	8030	167
9·040	·000 8706		9·120	·001 2586		9·200	·001 8197	

log (e sin e)	log λ		log (e sin e)	log λ		log (e sin e)	log λ	
9·200	·001 8197	84	9·240	·002 1881	101	9·280	·002 6312	122
·201	8281	84	·241	1982	102	·281	6434	122
·202	8365	85	·242	2084	102	·282	6556	123
·203	8450	85	·243	2186	102	·283	6679	123
·204	8535	86	·244	2288	103	·284	6802	124
·205	·001 8621	86	·245	·002 2391	104	·285	·002 6926	124
·206	8707	86	·246	2495	104	·286	7050	125
·207	8793	87	·247	2599	104	·287	7175	126
·208	8880	88	·248	2703	105	·288	7301	126
·209	8968	87	·249	2808	105	·289	7427	127
9·210	·001 9055	88	9·250	·002 2913	106	9·290	·002 7554	127
·211	9143	89	·251	3019	107	·291	7681	128
·212	9232	89	·252	3126	107	·292	7809	129
·213	9321	89	·253	3233	107	·293	7938	129
·214	9410	90	·254	3340	108	·294	8067	130
·215	·001 9500	90	·255	·002 3448	108	·295	·002 8197	130
·216	9590	90	·256	3556	109	·296	8327	131
·217	9680	91	·257	3665	109	·297	8458	131
·218	9771	91	·258	3774	110	·298	8589	132
·219	9862	92	·259	3884	111	·299	8721	133
9·220	·001 9954	92	9·260	·002 3995	111	9·300	·002 8854	134
·221	·002 0046	93	·261	4106	111	·301	8988	134
·222	0139	93	·262	4217	112	·302	9122	134
·223	0232	93	·263	4329	112	·303	9256	135
·224	0325	94	·264	4441	113	·304	9391	136
·225	·002 0419	95	·265	·002 4554	114	·305	·002 9527	137
·226	0514	95	·266	4668	114	·306	9664	137
·227	0609	95	·267	4782	114	·307	9801	138
·228	0704	96	·268	4896	115	·308	·002 9939	138
·229	0800	96	·269	5011	116	·309	·003 0077	139
9·230	·002 0896	96	9·270	·002 5127	116	9·310	·003 0216	140
·231	0992	97	·271	5243	117	·311	0356	140
·232	1089	97	·272	5360	117	·312	0496	141
·233	1186	98	·273	5477	117	·313	0637	142
·234	1284	99	·274	5594	119	·314	0779	142
·235	·002 1383	99	·275	·002 5713	119	·315	·003 0921	143
·236	1482	99	·276	5832	119	·316	1064	143
·237	1581	99	·277	5951	120	·317	1207	145
·238	1680	100	·278	6071	120	·318	1352	145
·239	1780	101	·279	6191	121	·319	1497	145
9·240	·002 1881		9·280	·002 6312		9·320	·003 1642	

log (e sin e)	log λ		log (e sin e)	log λ		log (e sin e)	log λ	
9·320	·003 1642	146	9·360	·003 8053	176	9·400	·004 5767	211
·321	1788	147	·361	8229	177	·401	5978	213
·322	1935	148	·362	8406	178	·402	6191	214
·323	2093	148	·363	8584	178	·403	6405	214
·324	2231	149	·364	8762	179	·404	6619	216
·325	·003 2380	150	·365	·003 8941	180	·405	·004 6835	217
·326	2530	150	·366	9121	181	·406	7052	217
·327	2680	151	·367	9302	182	·407	7269	219
·328	2831	152	·368	9484	183	·408	7488	220
·329	2983	153	·369	9667	183	·409	7708	220
9·330	·003 3136	153	9·370	·003 9850	184	9·410	·004 7928	222
·331	3289	154	·371	·004 0034	186	·411	8150	223
·332	3443	154	·372	0220	186	·412	8373	224
·333	3597	156	·373	0406	186	·413	8597	224
·334	3753	156	·374	0592	188	·414	8821	226
·335	·003 3909	157	·375	·004 0780	189	·415	·004 9047	227
·336	4066	157	·376	0969	189	·416	9274	228
·337	4213	158	·377	1158	191	·417	9502	229
·338	4381	159	·378	1349	191	·418	9731	230
·339	4540	160	·379	1540	192	·419	·004 9961	231
9·340	·003 4700	160	9·380	·004 1732	193	9·420	·005 0192	233
·341	4860	161	·381	1925	194	·421	0425	233
·342	5021	162	·382	2119	195	·422	0658	234
·343	5183	163	·383	2314	195	·423	0892	236
·344	5346	164	·384	2509	197	·424	1128	236
·345	·003 5510	164	·385	·004 2706	197	·425	·005 1364	238
·346	5674	164	·386	2903	199	·426	1602	239
·347	5838	166	·387	3102	199	·427	1841	240
·348	6004	167	·388	3301	200	·428	2081	241
·349	6171	167	·389	3501	202	·429	2322	242
9·350	·003 6338	168	9·390	·004 3703	202	9·430	·005 2564	243
·351	6506	169	·391	3905	203	·431	2807	244
·352	6675	169	·392	4108	204	·432	3051	246
·353	6844	171	·393	4312	205	·433	3297	246
·354	7015	171	·394	4517	206	·434	3543	248
·355	·003 7186	172	·395	·004 4723	207	·435	·005 3791	249
·356	7358	173	·396	4930	207	·436	4040	250
·357	7531	173	·397	5137	209	·437	4290	251
·358	7704	174	·398	5346	210	·438	4541	253
·359	7878	175	·399	5556	211	·439	4794	253
9·360	·003 8053		9·400	·004 5767		9·440	·005 5047	

log(sine)	log λ		log(sine)	log λ		log(sine)	log λ	
9·440	·005 5047	255	9·480	·006 6215	307	9·520	·007 9658	369
·441	·005 5302	256	·481	·006 6522	308	·521	·008 0027	371
·442	·005 5558	257	·482	·006 6830	309	·522	·008 0398	372
·443	·005 5815	258	·483	·006 7139	311	·523	·008 0770	374
·444	·005 .6073	260	·484	·006 7450	313	·524	·008 1144	376
·445	·005 6333	260	·485	·006 7763	313	·525	·008 1520	378
·446	·005 6593	262	·486	·006 8076	315	·526	·008 1898	380
·447	·005 6855	263	·487	·006 8391	317	·527	·008 2178	381
·448	·005 7118	265	·488	·006 8708	318	·528	·008 2659	383
·449	·005 7383	265	·489	·006 9026	320	·529	·008 3042	385
9·450	·005 7648	267	9·490	·006 9346	321	9·530	·008 3427	386
·451	·005 7915	268	·491	·006 9667	323	·531	·008 3813	388
·452	·005 8183	270	·492	·006 9990	324	·532	·008 4201	391
·453	·005 8453	270	·493	·007 0314	326	·533	·008 4592	392
·454	·005 8723	272	·494	·007 0640	327	·534	·008 4984	394
·455	·005 8995	273	·495	·007 0967	328	·535	·008 5378	395
·456	·005 9268	274	·496	·c07 1295	330	·536	·008 5773	398
·457	·005 9542	276	·497	·007 1625	332	·537	·008 6171	399
·458	·005 9818	277	·498	·007 1957	333	·538	·008 6570	401
·459	·006 0095	278	·499	·007 2290	335	·539	·008 6971	403
9·460	·006 0373	279	9 500	·007 2625	337	9·540	·008 7374	405
·461	·006 0652	281	·501	·007 2962	338	.541	·008 7779	407
·462	·006 0933	282	·502	·007 3300	339	·542	·008 8186	409
·463	·006 1215	283	·503	·007 3639	341	·543	·008 8595	410
·464	·006 1498	285	·504	·007 3980	343	·544	·008 9005	413
·465	·006 1783	286	·505	·007 4323	344	·545	·008 9418	414
·466	·006 2069	287	·506	·007 4667	346	·546	·008 9832	417
·467	·006 2356	289	·507	·007 5013	347	·547	·009 0249	418
·468	·006 2645	290	·508	·007 5360	349	·548	·009 0667	420
·469	·006 2935	291	·509	·007 5709	351	·549	·009 1087	423
9·470	·006 3226	293	9·510	·007 6060	352	9·550	·009 1510	424
·471	·006 3519	294	·511	·007 6412	354	·551	·009 1934	426
·472	·006 3813	296	·512	·007 6766	356	·552	·009 2360	428
·473	·006 4109	297	·513	·007 7122	357	·553	·009 2788	430
·474	·006 4406	298	·514	·007 7479	359	·554	·009 3218	432
·475	·006 4704	299	·515	·007 7838	361	·555	·009 3650	434
·476	·006 5003	301	·516	·007 8199	362	·556	·009 4084	437
·477	·006 5304	302	·517	·007 8561	364	·557	·009 4521	438
·478	·006 5606	304	·518	·007 8925	366	·558	·009 4959	440
·479	·006 5910	305	·519	·007 9291	367	·559	·009 5399	442
9·480	·006 6215		9·520	·007 9658		9·560	·009 5841	

log (e sin e)	log λ		log (e sin e)	log λ		log (e sin e)	log λ	
9.560	.009 5841	445	9.600	.011 5331	267	9.620	.012 6523	293
.561	.009 6286	446		.011 5598	268		.012 6816	294
.562	.009 6732	449	.601	.011 5866	268	.621	.012 7110	295
.563	.009 7181	450		.011 6134	269		.012 7405	296
.564	.009 7631	453	.602	.011 6403	270	.622	.012 7701	296
.565	.009 8084	455		.011 6673	271		.012 7997	297
.566	.009 8539	457	.603	.011 6944	271	.623	.012 8294	297
.567	.009 8996	459		.011 7215	272		.012 8591	298
.568	.009 9455	461	.604	.011 7487	272	.624	.012 8889	299
.569	.009 9916	463		.011 7759	273		.012 9188	300
9.570	.010 0379	466	.605	.011 8032	273	.625	.012 9488	300
.571	.010 0845	468		.011 8305	275		.012 9788	301
.572	.010 1313	469	.606	.011 8580	275	.626	.013 0089	302
.573	.010 1782	472		.011 8855	275		.013 0391	302
.574	.010 2254	475	.607	.011 9130	276	.627	.013 0693	303
.575	.010 2729	476		.011 9406	277		.013 0996	304
.576	.010 3205	479	.608	.011 9683	277	.628	.013 1300	305
.577	.010 3684	481		.011 9960	278		.013 1605	305
.578	.010 4165	483	.609	.012 0238	279	.629	.013 1910	306
.579	.010 4648	485		.012 0517	279		.013 2216	307
9.580	.010 5133	488	9.610	.012 0796	280	9.630	.013 2523	307
.581	.010 5621	490		.012 1076	281		.013 2830	308
.582	.010 6111	492	.611	.012 1357	282	.631	.013 3138	309
.583	.010 6603	494		.012 1639	282		.013 3447	309
.584	.010 7097	497	.612	.012 1921	282	.632	.013 3756	311
.585	.010 7594	499		.012 2203	284		.013 4067	311
.586	.010 8093	502	.613	.012 2487	284	.633	.013 4378	311
.587	.010 8595	504		.012 2771	284		.013 4689	313
.588	.010 9099	506	.614	.012 3055	285	.634	.013 5002	313
.589	.010 9605	508		.012 3340	286		.013 5315	314
9.590	.011 0113	511	.615	.012 3626	287	.635	.013 5629	315
.591	.011 0624	513		.012 3913	287		.013 5944	315
.592	.011 1137	516	.616	.012 4200	288	.636	.013 6259	316
.593	.011 1653	518		.012 4488	289		.013 6575	317
.594	.011 2171	521	.617	.012 4777	289	.637	.013 6892	318
.595	.011 2692	523		.012 5066	290		.013 7210	318
.596	.011 3215	525	.618	.012 5356	291	.638	.013 7528	319
.597	.011 3740	528		.012 5647	291		.013 7847	320
.598	.011 4268	530	.619	.012 5938	292	.639	.013 8167	320
.599	.011 4798	533		.012 6230	293		.013 8487	223
9.600	.011 5331		9.620	.012 6523		9.640	.013 8809	

log (e sin e)	log λ		log (e sin e)	log λ		log (e sin e)	log λ	
9·640	·013 8809	322	9·660	·015 2296	353	9·680	·016 7103	389
	·013 9131	323		·015 2649	355		·016 7492	389
·641	·013 9454	323	·661	·015 3004	355	·681	·016 7881	390
	·013 9777	324		·015 3359	356		·016 8271	391
·642	·014 0101	325	·662	·015 3715	357	·682	·016 8662	392
	·014 0426	326		·015 4072	358		·016 9054	393
·643	·014 0752	326	·663	·015 4430	358	·683	·016 9447	393
	·014 1078	328		·015 4788	360		·016 9840	395
·644	·014 1406	328	·664	·015 5148	360	·684	·017 0235	395
	·014 1734	329		·015 5508	361		·017 0630	397
·645	·014 2063	330	·665	·015 5869	362	·685	·017 1027	397
	·014 2393	330		·015 6231	363		·017 1424	399
·646	·014 2723	332	·666	·015 6594	363	·686	·017 1823	399
	·014 3055	332		·015 6957	365		·017 2222	400
·647	·014 3387	332	·667	·015 7322	365	·687	·017 2622	401
	·014 3719	334		·015 7687	366		·017 3023	402
·648	·014 4053	334	·668	·015 8053	367	·688	·017 3425	403
	·014 4387	335		·015 8420	368		·017 3828	404
·649	·014 4722	336	·669	·015 8788	369	·689	·017 4232	405
	·014 5058	337		·015 9157	370		·017 4637	406
9·650	·014 5395	337	9·670	·015 9527	370	9·690	·017 5043	407
	·014 5732	338		·015 9797	371		·017 5450	408
·651	·014 6070	339	·671	·016 0268	373	·691	·017 5858	409
	·014 6409	340		·016 0641	373		·017 6267	409
·652	·014 6749	341	·672	·016 1014	374	·692	·017 6676	411
	·014 7090	341		·016 1388	375		·017 7087	412
·653	·014 7431	343	·673	·016 1763	375	·693	·017 7499	412
	·014 7774	343		·016 2138	377		·017 7911	414
·654	·014 8117	343	·674	·016 2515	377	·694	·017 8325	414
	·014 8460	345		·016 2892	379		·017 8739	416
·655	·014 8805	345	·675	·016 3271	379	·695	·017 9155	416
	·014 9150	347		·016 3650	380		·017 9571	418
·656	·014 9497	347	·676	·016 4030	381	·696	·017 9989	418
	·014 9844	347		·016 4411	382		·018 0407	419
·657	·015 0191	349	·677	·016 4793	383	·697	·018 0826	421
	·015 0540	350		·016 5176	384		·018 1247	421
·658	·015 0890	350	·678	·016 5560	384	·698	·018 1668	422
	·015 1240	351		·016 5944	386		·018 2090	424
·659	·015 1591	352	·679	·016 6330	386	·699	·018 2514	424
	·015 1943	353		·016 6716	387		·018 2938	425
9·660	·015 2296		9·680	·016 7103		9·700	·018 3363	

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log (e sin e)	log λ		log (e sin e)	log λ		log (e sin e)	log λ	
9·700	·018 3363	427	9·720	·020 1221	468	9·740	·022 0835	514
	·018 3790	427		·020 1689	469		·022 1349	516
·701	·018 4217	428	·721	·020 2158	471	·741	·022 1865	517
	·018 4645	430		·020 2629	471		·022 2382	518
·702	·018 5075	430	·722	·020 3100	473	·742	·022 2900	519
	·018 5505	432		·020 3573	474		·022 3419	520
·703	·018 5937	432	·723	·020 4047	475	·743	·022 3939	522
	·018 6369	433		·020 4522	476		·022 4461	523
·704	·018 6802	435	·724	·020 4998	477	·744	·022 4984	524
	·018 7237	435		·020 5475	478		·022 5508	525
·705	·018 7672	437	·725	·020 5953	479	·745	·022 6033	527
	·018 8109	437		·020 6432	481		·022 6560	528
·706	·018 8546	438	·726	·020 6913	481	·746	·022 7088	529
	·018 8984	440		·020 7394	483		·022 7617	530
·707	·018 9424	441	·727	·020 7877	484	·747	·022 8147	532
	·018 9865	441		·020 8361	485		·022 8679	533
·708	·019 0306	443	·728	·020 8846	486	·748	·022 9212	534
	·019 0749	443		·020 9332	487		·022 9746	535
·709	·019 1192	445	·729	·020 9819	489	·749	·023 0281	537
	·019 1637	446		·021 0308	490		·023 0818	538
9·710	·019 2083	447	9·730	·021 0798	490	9·750	·023 1356	539
	·019 2530	447		·021 1288	492		·023 1895	540
·711	·019 2977	449	·731	·021 1780	493	·751	·023 2435	542
	·019 3426	450		·021 2273	494		·023 2977	543
·712	·019 3876	451	·732	·021 2767	496	·752	·023 3520	544
	·019 4327	452		·021 3263	496		·023 4064	546
·713	·019 4779	453	·733	·021 3759	498	·753	·023 4610	546
	·019 5232	455		·021 4257	499		·023 5156	548
·714	·019 5687	455	·734	·021 4756	500	·754	·023 5704	550
	·019 6142	456		·021 5256	501		·023 6254	551
·715	·019 6598	458	·735	·021 5757	503	·755	·023 6805	552
	·019 7056	458		·021 6260	503		·023 7357	553
·716	·019 7514	460	·736	·021 6763	505	·756	·023 7910	554
	·019 7974	460		·021 7268	506		·023 8464	556
·717	·019 8434	462	·737	·021 7774	507	·757	·023 9020	557
	·019 8896	463		·021 8281	509		·023 9577	559
·718	·019 9359	464	·738	·021 8790	509	·758	·024 0136	560
	·019 9823	465		·021 9299	511		·024 0696	561
·719	·020 0288	466	·739	·021 9810	512	·759	·024 1257	562
	·020 0754	467		·022 0322	513		·024 1819	564
9·720	·020 1221		9·740	·022 0835		9·760	·024 2383	

log (e sin e)	log λ		log (e sin e)	log λ		log (e sin e)	log λ	
9·760	·024 2383	565	9·780	·026 6061	621	9·800	·029 2083	683
	·024 2948	567		·026 6682	622		·029 2766	684
·761	·024 3515	568	·781	·026 7304	624	·801	·029 3450	686
	·024 4083	569		·026 7928	626		·029 4136	687
·762	·024 4652	570	·782	·026 8554	627	·802	·029 4823	689
	·024 5222	572		·026 9181	628		·029 5412	691
·763	·024 5794	573	·783	·026 9809	630	·803	·029 6203	693
	·024 6367	575		·027 0439	631		·029 6896	694
·764	·024 6942	576	·784	·027 1070	633	·804	·029 7590	695
	·024 7518	577		·027 1703	634		·029 8285	698
·765	·024 8095	579	·785	·027 2337	636	·805	·029 8983	699
	·024 8674	580		·027 2973	638		·029 9682	700
·766	·024 9254	581	·786	·027 3611	639	·806	·030 0382	703
	·024 9835	583		·027 4250	640		·030 1085	704
767	·025 0418	584	·787	·027 4890	642	·807	·030 1789	705
	·025 1002	585		·027 5532	643		·030 2494	707
·768	·025 1587	587	·788	·027 6175	645	·808	·030 3201	709
	·025 2174	588		·027 6820	647		·030 3910	711
·769	·025 2762	590	·789	·027 7467	648	·809	·030 4621	713
	·025 3352	591		·027 8115	649		·030 5334	714
9·770	·025´3943	592	9·790	·027 8764	651	9·810	·030 6048	715
	·025 4535	594		·027 9415	653		·030 6763	718
·771	·025 5129	595	·791	·028 0068	654	·811	·030 7481	719
	·025 5724	597		·028 0722	656		·030 8200	721
·772	·025 6321	598	·792	·028 1378	657	·812	·030 8921	722
	·025 6919	599		·028 2035	659		·030 9643	725
·773	·025 7518	601	·793	·028 2694	660	·813	·031 0368	726
	·025 8119	602		·028 3354	662		·031 1094	727
·774	·025 8721	604	·794	·028 4016	664	·814	·031 1821	730
	·025 9325	605		·028 4680	665		·031 2551	731
·775	·025 9930	607	·795	·028 5345	667	·815	·031 3282	733
	·026 0537	608		·028 6012	668		·031 4015	734
·776	·026 1145	609	·796	·028 6680	670	·816	·031 4749	737
	·026 1754	611		·028 7350	671		·031 5486	738
·777	·026 2365	612	·797	·028 8021	673	·817	·031 6224	740
	·026 2977	614		·028 8694	675		·031 6964	742
·778	·026 3591	615	·798	·028 9369	676	·818	·031 7706	743
	·026 4206	617		·029 0045	678		·031 8449	745
·779	·026 4823	618	·799	·029 0723	679	·819	·031 9194	747
	·026 5441	620		·029 1402	681		·031 9941	749
9·780	·026 6061		9·800	·029 2083		9·820	·032 0690	

log (e sin e)	log λ		log (e sin e)	log λ		log (e sin e)	log λ	
9·820	·032 0690	750	9·840	·035 2146	825	9·860	·038 6744	908
	·032 1440	753		·035 2971	827		·038 7652	910
·821	·032 2193	754	·841	·035 3798	830	·861	·038 8562	912
	·032 2947	756		·035 4628	831		·038 9474	915
·822	·032 3703	757	·842	·035 5459	833	·862	·039 0389	917
	·032 4460	760		·035 6292	835		·039 1306	919
·823	·032 5220	761	·843	·035 7127	838	·863	·039 2225	921
	·032 5981	763		·035 7965	839		·039 3146	923
·824	·032 6744	765	·844	·035 8804	841	·864	·039 4069	925
	·032 7509	767		·035 9645	843		·039 4994	928
·825	·032 8276	768	·845	·036 0488	846	·865	·039 5922	930
	·032 9044	771		·036 1334	847		·039 6852	932
·826	·032 9815	772	·846	·036 2181	849	·866	·039 7784	935
	·033 0587	774		·036 3030	852		·039 8719	936
·827	·033 1361	776	·847	·036 3882	853	·867	·039 9655	939
	·033 2037	778		·036 4735	855		·040 0594	941
·828	·033 2915	779	·848	·036 5590	858	·868	·040 1535	944
	·033 3694	782		·036 6448	859		·040 2479	945
·829	·033 4476	783	·849	·036 7307	862	·869	·040 3424	948
	·033 5259	785		·036 8169	863		·040 4372	951
9·830	·033 6044	787	9·850	·036 9032	866	9·870	·040 5323	952
	·033 6831	789		·036 9898	868		·040 6275	955
·831	·033 7620	791	·851	·037 0766	870	·871	·040 7230	957
	·033 8411	792		·037 1636	871		·040 8187	959
·832	·033 9203	795	·852	·037 2507	874	·872	·040 9146	962
	·033 9998	796		·037 3381	876		·041 0108	964
·833	·034 0794	799	·853	·037 4257	879	·873	·041 1072	966
	·034 1593	800		·037 5136	880		·041 2038	968
·834	·034 2393	802	·854	·037 6016	882	·874	·041 3006	971
	·034 3195	804		·037 6898	885		·041 3977	973
·835	·034 3999	806	·855	·037 7783	886	·875	·041 4950	976
	·034 4805	808		·037 8669	889		·041 5926	978
·836	·034 5613	810	·856	·037 9558	891	·876	·041 6904	980
	·034 6423	811		·038 0449	893		·041 7884	983
·837	·034 7234	814	·857	·038 1342	895	·877	·041 8867	985
	·034 8048	816		·038 2237	897		·041 9852	987
·838	·034 8864	817	·858	·038 3134	899	·878	·042 0839	990
	·034 9681	820		·038 4033	902		·042 1829	992
·839	·035 0501	821	·859	·038 4935	903	·879	·042 2821	994
	·035 1322	824		·038 5838	906		·042 3815	997
9·840	·035 2146		9·860	·038 6744		9·880	·042 4812	

Ephemerides of the Satellites of Saturn, 1890–91. By A. Marth.

In the following ephemerides the five inner satellites are assumed to move in circular orbits in the plane of the ring, the ascending node N and inclination J of which, in reference to the plane parallel to the Earth's equator, are assumed to be

for 1891·0, $N = 126°·7433$; $J = 6°·9802.$

These and the corresponding values, adopted in my previous ephemerides, depend on a modification of Bessel's determination, which I had deduced, some thirty years ago, by taking into account the observed disappearances and reappearances of 1848–49, and by applying corrections to the computed places of *Saturn*, and also a correction pointed out by Beima (" De Annulo Saturni," p. 87). At the time I considered this modification as a merely preliminary one, which would be superseded a few years later, when advantage would have been taken of the favourable opportunities of the years 1861–62 for settling several questions concerning the ball and ring of *Saturn*, and especially whether there is any sensible deviation of the ring from the plane of *Saturn's* equator, in which case the effect would show itself in the observed position-angles of the ring, when it appears as a narrow ellipse. This expectation of thirty years ago having remained unfulfilled, it is high time that, at the end of another revolution of *Saturn*, these questions should be settled or substantial progress towards their settlement made, and it is to be hoped that the superior telescopes and micrometers now available will be devoted to observations of *Saturn* and its satellites during the next two apparitions of the planet.

In the following table P denotes the position-angle of the minor axis of the ring, $L + 180°$ the planetocentric longitude of the Earth referred to the assumed plane of the ring, $\Lambda + 180°$ that of the Sun or $\Lambda - L$ the difference between the two. The last column contains the values of $\log v = 0·950 - \log \Delta$, the *Nautical Almanac* values of the distances Δ of the planet from the Earth being so altered as to take the equation of light into account.

Greenwich Noon.	P	L	Latitude of Earth above plane of Ring	Sun above plane of Ring	$\Lambda - L$	$\log v$
1890.	°	°	°	°	°	
Oct. 29	354·600	166·631	−3·339	−5·692	−4·202	9·954275
Nov. 3	·635	167·039	3·140	5·615	4·452	·957224
8	·667	167·420	2·956	5·537	4·676	·960358
13	·697	167·773	2·789	5·460	4·872	·963661
18	·725	168·096	2·638	5·383	5·037	·967117
23	·750	168·387	2·505	5·305	5·170	·970704
28	·772	168·644	2·392	5·228	5·270	9·974402

Greenwich Noon.	P	L	Latitude of Earth | Sun above plane of Ring		Δ−L	log v
1890.	°	°	°	°	°	
Dec. 3	354·791	168·865	−2·298	−5·150	−5·334	9·978189
8	·806	169·048	2·225	5·073	5·360	·982041
13	·819	169·193	2·173	4·995	5·348	·985933
18	·828	169·298	2·142	4·918	5·296	·989832
23	·833	169·363	2·133	4·840	5·204	·993708
28	·835	169·387	2·146	4·763	5·071	9·997529
1891.						
Jan. 2	354·833	169·371	−2·180	−4·685	−4·898	0·001264
7	·828	169·314	2·235	4·608	4·684	·004881
12	·819	169·217	2·311	4·530	4·431	·008341
17	·807	169·082	2·408	4·453	4·139	·011610
22	·791	168·910	2·523	4·375	3·811	·014652
27	·773	168·704	2·655	4·298	3·449	·017438
Feb. 1	354·752	168·466	−2·802	−4·220	−3·055	0·019936
6	·729	168·199	2·963	4·143	2·632	·022118
11	·704	167·907	3·136	4·065	2·184	·023956
16	·676	167·595	3·318	3·988	1·716	·025427
21	·648	167·266	3·506	3·910	1·231	·026515
26	·619	166·924	3·699	3·832	−0·734	·027209
Mar. 3	354·589	166·576	−3·893	−3·755	−0·230	0·027501
8	·559	166·226	4·086	3·677	+0·276	·027387
13	·530	165·878	4·275	3·600	0·779	·026866
18	·501	165·538	4·457	3·522	1·275	·025948
23	·474	165·209	4·630	3·445	1·759	·024647
28	·448	164·897	4·793	3·367	2·226	·022980
Apr. 2	354·424	164·607	−4·943	−3·289	+2·672	0·020968
7	·402	164·341	5·077	3·212	3·093	·018632
12	·382	164·103	5·195	3·134	3·486	·015999
17	·365	163·895	5·295	3·057	3·849	·013100
22	·351	163·720	5·376	2·979	4·179	·009968
27	·340	163·580	5·438	2·901	4·473	·006634
May 2	354·332	163·477	−5·479	−2·824	+4·731	0·003129
7	·327	163·411	5·500	2·746	4·952	9·999484
12	·325	163·384	5·500	2·669	5·134	·995730
17	·326	163·395	5·479	2·591	5·277	·991902
22	·330	163·444	5·437	2·514	5·382	·988028
27	·338	163·532	5·376	2·436	5·449	·984137
June 1	354·348	163·657	−5·295	−2·359	+5·479	9·980254

Greenwich Noon.	P	L	Latitude of Earth | Sun above plane of Ring		A−L	log ν
1891.	°	°	°	°	°	
June 6	354·362	163·818	−5·194	−2·281	+5·472	9·976404
11	·378	164·015	5·075	2·204	5·429	·972611
16	·397	164·246	4·938	2·126	5·352	·968900
21	·419	164·510	4·785	2·049	5·243	·965290
26	·443	164·805	4·615	1·971	5·102	·961799
July 1	354·470	165·129	−4·430	−1·894	+4·932	9·958443
6	·500	165·481	4·231	1·816	4·734	·955236
11	·532	165·860	4·019	1·739	4·509	·952197
16	354·566	166·263	−3·795	−1·661	+4·259	9·949338

The values of the apparent equatorial diameter of the ball and of the diameter of the outer rim of the ring depend on Bessel's determinations. The assumed proportion of the polar axis of the ball to the equatorial diameter is 0·900. The " phase " or the defect of illumination of the equatorial diameter is before opposition on the preceding side, and after opposition on the following side.

In the tables for the five satellites a and b denote the semi-axes of the apparent orbits, $l-L$ the orbital longitudes of the satellites reckoned from the points which are in superior conjunction with the planet's centre or in opposition to the Earth in longitude. By adding to $l-L$ the value of L from the preceding table, the longitudes l are found. These longitudes, which are the orbital longitudes from the ascending node added to the right ascension N of the ascending node, are corrected for the equation of light, and depend on the following assumed values, which contain already the equation corresponding to the distance [0·950] :—

Greenwich Noon.		Mimas. l_1	Enceladus. l_2	Tethys. l_3	Dione. l_4	Rhea. l_5
		°	°	°	°	°
1890	Oct. 19	303·551	116·528	45·280	308·530	179·744
	Nov. 18	243·582	78·485	6·208	294·579	50·447
	Dec. 18	183·616	40·442	327·136	280·627	281·150
1891	Jan. 17	123·652	2·399	288·063	266·676	151·852
	Feb. 16	63·690	324·356	248·991	252·724	22·555
	Mar. 18	3·730	286·313	209·918	238·773	253·257
	Apr. 17	303·773	248·270	170·846	224·821	123·960
	May 17	243·818	210·227	131·773	210·870	354·663
	June 16	183·864	172·184	92·700	196·918	225·365
	July 16	123·913	134·141	53·627	182·967	96·068

The values of P, a, b, and $l-L$ are to be interpolated directly for the times for which the apparent positions of the satellites are

required, and the rectangular coordinates x and y reckoned parallel to the major and minor axis of the ring, or, if polar co-ordinates are wanted, the position-angles p and distances s of the satellites in reference to the planet's centre are then found by means of the formulæ

$$s \sin (p-\mathrm{P}) = x = a \sin (l-\mathrm{L})$$
$$s \cos (p-\mathrm{P}) = y = b \cos (l-\mathrm{L}).$$

Greenwich Noon.	Diameter of Ball.			Axis of Ring.		*Mimas.*			
	Equat.	Phase.	Polar.	Major	Minor	a_1	b_1	$l_1 - \mathrm{L}$	Diff.
1890.								°	°
Oct. 29	16.43	0.022	14.80	37.88	2.21	25.88	−1.51	354.75	1909.74
Nov. 3	16.54	.025	14.90	38.14	2.09	26.06	−1.43	104.49	.78
8	16.67	.028	15.00	38.42	1.98	26.25	1.35	214.27	.82
13	16.79	.030	15.12	38.71	1.88	26.45	1.29	324.09	.85
18	16.93	.033	15.24	39.02	1.80	26.66	1.23	73.94	.89
23	17.07	.035	15.36	39.34	1.72	26.88	1.18	183.83	.93
28	17.21	.036	15.49	39.68	1.66	27.11	1.13	293.76	1909.97
Dec. 3	17.36	.037	15.63	40.03	1.61	27.35	−1.10	33.73	1910.00
8	17.52	.038	15.77	40.38	1.57	27.59	1.07	153.73	.04
13	17.68	.038	15.91	40.75	1.54	27.84	1.06	263.77	.08
18	17.84	.038	16.05	41.11	1.54	28.09	1.05	13.85	.12
23	18.00	.037	16.20	41.48	1.54	28.34	1.05	123.97	.16
28	18.15	.035	16.34	41.85	1.57	28.59	1.07	234.13	.19
1891. Jan. 2	18.31	0.033	16.48	42.21	1.61	28.84	−1.10	344.32	1910.22
7	18.46	.031	16.62	42.56	1.66	29.08	1.13	94.54	.26
12	18.61	.028	16.75	42.90	1.73	29.31	1.18	204.80	.28
17	18.75	.024	16.88	43.23	1.82	29.53	1.24	315.08	.31
22	18.88	.021	17.00	43.53	1.92	29.74	1.31	65.39	.34
27	19.01	.017	17.11	43.81	2.03	29.93	1.39	175.73	.35
Feb. 1	19.12	.014	17.21	44.07	2.15	30.11	−1.47	286.08	1910.37
6	19.21	.010	17.30	44.29	2.29	30.26	1.56	36.45	.38
11	19.29	.007	17.37	44.48	2.43	30.39	1.66	146.83	.38
16	19.36	.004	17.43	44.63	2.58	30.49	1.76	257.21	.38
21	19.41	.002	17.47	44.74	2.74	30.57	1.87	7.59	.38
26	19.44	.001	17.50	44.81	2.89	30.62	1.97	117.97	.37
Mar. 3	19.45	...	17.52	44.84	3.04	30.64	−2.08	228.34	1910.35
8	19.45	...	17.51	44.83	3.19	30.63	2.18	338.69	.33
13	19.42	.001	17.49	44.77	3.34	30.59	2.28	89.02	.31
18	19.38	.002	17.46	44.68	3.47	30.53	2.37	199.33	.28
23	19.32	.005	17.40	44.55	3.60	30.44	2.46	309.61	.24
28	19.25	.007	17.34	44.38	3.71	30.32	2.53	59.85	.21

Greenwich Noon	Diameter of Ball. Equat.	Phase.	Polar.	Axis of Ring Major	Minor	Mimas. a_1	b_1	l_1-L	Diff.
1891.	"	"	"	"	"	"	"	°	°
Apr. 2	19·16	0·011	17·26	44·17	3·81	30·18	−2·60	170·06	1910·18
7	19·06	·014	17·17	43·93	3·89	30·02	2·66	280·24	·13
12	18·94	·018	17·07	43·67	3·95	29·84	2·70	30·37	·09
17	18·82	·021	16·95	43·38	4·00	29·64	2·74	140·46	·04
22	18·68	·025	16·83	43·07	4·04	29·42	2·76	250·50	1910·00
27	18·54	·028	16·70	42·74	4·05	29·20	2·77	0·50	1909·95
May 2	18·39	·031	16·57	42·39	4·05	28·96	−2·77	110·45	·91
7	18·24	·034	16·43	42·04	4·03	28·72	2·75	220·36	·87
12	18·08	·036	16·29	41·68	3·99	28·47	2·73	330·23	·82
17	17·92	·038	16·15	41·31	3·94	28·22	2·69	80·05	·78
22	17·76	·039	16·00	40·94	3·88	27·97	2·65	189·83	·74
27	17·60	·040	15·86	40·58	3·80	27·72	2·60	299·59	·70
June 1	17·45	·040	15·72	40·22	3·71	27·48	−2·54	49·27	1909·66
6	17·29	·039	15·58	39·86	3·61	27·24	2·47	158·93	·63
11	17·14	·038	15·44	39·52	3·50	27·00	2·39	268·56	·60
16	17·00	·037	15·31	39·18	3·37	26·77	2·30	18·16	·57
21	16·86	·035	15·18	38·86	3·24	26·55	2·21	127·73	·54
26	16·72	·033	15·06	38·54	3·10	26·33	2·12	237·27	·51
July 1	16·59	·031	14·94	38·25	2·95	26·13	−2·02	346·78	·50
6	16·47	·028	14·83	37·97	2·80	25·94	1·91	96·28	·48
11	16·36	·025	14·73	37·70	2·64	25·76	1·81	205·76	1909·46
16	16·25	0·022	14·63	37·45	2·48	25·59	−1·69	315·22	

Greenwich Noon	Enceladus. a_2	b_2	l_2-L	Diff.	Tethys. a_3	b_3	l_3-L	Diff.
1890.	"	"	°	°	"	"	°	°
Oct. 29	33·20	−1·93	55·71	1313·36	41·10	−2·39	344·53	953·16
Nov. 3	33·43	−1·83	289·07	·38	41·38	−2·27	217·69	·18
8	33·67	1·74	162·45	·42	41·68	2·15	90·87	·22
13	33·93	1·65	35·87	·45	42·00	2·04	324·09	·25
18	34·20	1·57	269·32	·49	42·34	1·95	197·34	·28
23	34·48	1·51	142·81	·53	42·69	1·87	70·62	·32
28	34·78	1·45	16·34	·56	43·05	1·80	303·94	·36
Dec. 3	35·09	−1·41	249·90	1313·60	43·43	−1·74	177·30	953·39
8	35·40	1·37	123·50	·64	43·82	1·70	50·69	·43
13	35·72	1·35	357·14	·68	44·21	1·68	284·13	·47
18	36·04	1·35	230·82	·72	44·61	1·67	157·60	·51
23	36·36	1·35	104·54	·75	45·01	1·68	31·11	·55
28	36·68	1·37	338·29	·79	45·41	1·70	264·66	

	Enceladus.				*Tethys.*			
Greenwich Noon. 1891.	a_2	b_2	l_2-L	Diff.	a_2	b_2	l_2-L	Diff.
Jan. 2	37·00	−1·41	212·08	1313·83	45·80	−1·74	138·25	953·63
7	37·31	1·46	85·91	·87	46·18	1·80	11·88	·66
12	37·61	1·52	319·78	·89	46·55	1·88	245·54	·70
17	37·89	1·59	193·67	·92	46·90	1·97	119·24	·72
22	38·16	1·68	67·59	·95	47·23	2·08	352·96	·76
27	38·40	1·78	301·54	·97	47·54	2·20	226·72	·78
Feb. 1	38·62	−1·89	175·51	1313·99	47·81	−2·34	100·50	953·80
6	38·82	2·01	49·50	1314·01	48·05	2·48	334·30	·82
11	38·98	2·13	283·51	·02	48·25	2·64	208·12	·83
16	39·11	2·26	157·53	·02	48·42	2·80	81·95	·84
21	39·21	2·40	31·55	·02	48·54	2·97	315·79	·84
26	39·28	2·53	265·57	·01	48·62	3·14	189·63	·84
Mar. 3	39·30	−2·67	139·58	1314·01	48·65	−3·30	63·47	953·84
8	39·29	2·80	13·59	1313·99	48·64	3·47	297·31	·82
13	39·24	2·93	247·58	·97	48·58	3·62	171·13	·81
18	39·16	3·04	121·55	·95	48·48	3·77	44·94	·79
23	39·04	3·15	355·50	·93	48·33	3·90	278·73	·77
28	38·89	3·25	229·43	·89	48·15	4·02	152·50	·73
Apr. 2	38·71	−3·34	103·32	1313·85	47·93	−4·13	26·23	953·71
7	38·51	3·41	337·17	·82	47·67	4·22	259·94	·67
12	38·28	3·47	210·99	·78	47·38	4·29	133·61	·63
17	38·02	3·51	84·77	·74	47·07	4·34	7·24	·59
22	37·75	3·54	318·51	·70	46·73	4·38	240·83	·56
27	37·46	3·55	192·21	·66	46·37	4·39	114·39	·51
May 2	37·16	−3·55	65·87	1313·61	46·00	−4·39	347·90	953·47
7	36·85	3·53	299·48	·57	45·61	4·37	221·37	·43
12	36·53	3·50	173·05	·52	45·22	4·33	94·80	·39
17	36·21	3·46	46·57	·49	44·82	4·28	328·19	·35
22	35·89	3·40	280·06	·45	44·42	4·21	201·54	·31
27	35·57	3·33	153·51	·41	44·03	4·12	74·85	·27
June 1	35·25	−3·25	26·92	1313·37	43·64	−4·03	308·12	953·24
6	34·94	3·16	260·29	·34	43·25	3·92	181·36	·20
11	34·64	3·06	133·63	·30	42·87	3·79	54·56	·16
16	34·34	2·96	6·93	·27	42·51	3·66	287·72	·14
21	34·06	2·84	240·20	·25	42·16	3·52	160·86	·11
26	33·78	2·72	113·45	·22	41·82	3·37	33·97	·08
July 1	33·52	−2·59	346·67	·20	41·50	−3·21	267·05	·05
6	33·28	2·46	219·87	·18	41·19	3·04	140·10	·04
11	33·05	2·32	93·05	1313·15	40·91	2·87	13·14	953·01
16	32·82	−2·17	326·20		40·64	−2·69	246·15	

	Dione.				Rhea.			
Greenwich Noon. 1889.	a_o	b_o	l_o-L	Diff.	a_1	b_1	l_1-L	Diff.
	"	"	°	°	"	"	°	°
Oct. 29	52·64	−3·07	16·49	657·32	73·52	−4·28	89·56	398·07
Nov. 3	53·00	−2·90	313·81	·35	74·02	−4·05	127·63	·10
8	53·38	2·75	251·16	·38	74·55	3·84	165·73	·13
13	53·79	2·62	188·54	·41	75·12	3·65	203·86	·16
18	54·22	2·50	125·95	·44	75·72	3·49	242·02	·20
23	54·67	2·39	63·39	·48	76·35	3·34	280·22	·23
28	55·14	2·30	0·87	·52	77·00	3·21	318·45	·27
Dec. 3	55·62	−2·23	298·39	657·55	77·68	−3·11	356·72	398·30
8	56·12	2·18	235·94	·59	78·37	3·04	35·02	·35
13	56·62	2·15	173·53	·64	79·07	3·00	73·37	·38
18	57·13	2·14	111·17	·67	79·79	2·98	111·75	·42
23	57·64	2·15	48·84	·71	80·50	3·00	150·17	·47
28	58·15	2·18	346·55	·75	81·21	3·04	188·64	·50
1891. Jan. 2	58·66	−2·23	284·30	657·78	81·91	−3·12	227·14	398·54
7	59·15	2·31	222·08	·83	82·60	3·22	265·68	·58
12	59·62	2·40	159·91	·86	83·26	3·36	304·26	·62
17	60·07	2·52	97·77	·89	83·89	3·52	342·88	·65
22	60·49	2·66	35·66	·92	84·48	3·72	21·53	·68
27	60·88	2·82	333·58	·95	85·02	3·94	60·21	·71
Feb. 1	61·23	−2·99	271·53	·98	85·51	−4·18	98·92	398·73
6	61·54	3·18	209·51	657·99	85·94	4·44	137·65	·76
11	61·80	3·38	147·50	658·01	86·31	4·72	176·41	·78
16	62·01	3·59	85·51	·02	86·60	5·01	215·19	·79
21	62·17	3·80	23·53	·03	86·82	5·30	253·98	·80
26	62·27	4·02	321·56	·03	86·96	5·61	292·78	·80
Mar. 3	62·31	−4·23	259·59	·02	87·02	−5·91	331·58	398·80
8	62·29	4·44	197·61	·01	86·99	6·20	10·38	·79
13	62·22	4·64	135·62	658·00	86·89	6·48	49·17	·78
18	62·09	4·83	73·62	657·99	86·71	6·74	87·95	·77
23	61·90	5·00	11·61	·96	86·45	6·98	126·72	·75
28	61·67	5·15	309·57	·93	86·12	7·20	165·47	·72
Apr. 2	61·38	−5·29	247·50	·91	85·72	−7·39	204·19	398·70
7	61·05	5·40	185·41	·87	85·26	7·55	242·89	·66
12	60·68	5·49	123·28	·84	84·74	7·67	281·55	·63
17	60·28	5·56	61·12	·80	84·18	7·77	320·18	·60
22	59·85	5·61	358·92	·77	83·57	7·83	358·78	·56
27	59·39	5·63	296·69	·73	82·93	7·86	37·34	·52
May 2	58·91	−5·63	234·42	657·68	82·27	−7·86	75·86	398·48

		Dione.				Rhea.		
Greenwich Noon. 1891.	a_4	b_4	l_4-L	Diff.	a_5	b_5	l_5-L	Diff.
	"	"	°	°	"	"	°	°
May 7	58·42	−5·60	172·10	657·64	81·58	−7·82	114·34	398·44
12	57·92	5·55	109·74	·60	80·88	7·75	152·78	·41
17	57·41	5·48	47·34	·56	80·17	7·65	191·19	·36
22	56·90	5·39	344·90	·53	79·46	7·53	229·55	·32
27	56·39	5·28	282·43	·49	78·75	7·38	267·87	·29
June 1	55·89	−5·16	219·92	657·45	78·05	−7·20	306·16	398·25
6	55·39	5·01	157·37	·42	77·36	7·00	344·41	·22
11	54·91	4·86	94·79	·38	76·68	6·78	22·63	·18
16	54·44	4·69	32·17	·35	76·03	6·55	60·81	·15
21	53·99	4·50	329·52	·32	75·40	6·29	98·96	·12
26	53·56	4·31	266·84	·29	74·80	6·02	137·08	·09
July 1	53·15	−4·11	204·13	·27	74·22	−5·73	175·17	·07
6	52·76	3·89	141·40	·25	73·68	5·44	213·24	·04
11	52·39	3·67	78·65	657·22	73·16	· 5·13	251·28	398·01
16	52·05	−3·44	15·87		72·68	−4·81	289·29	

Differences of right ascension and declination between Titan and Iapetus and the centre of Saturn.

		Titan.			Iapetus.	
Greenwich Noon. 1890.	a_6-A	δ_6-D	a_8-A	δ_8-D
	s	"	s	"
Oct. 29	+ 10·49	+ 10·0	− 0·54	−43·1
30	+ 11·07	+ 14·7	3·20	39·3
31	+ 9·84	+ 17·0	5·84	35·1
Nov. 1	+ 6·97	+ 16·3	8·45	30·7
2	+ 2·95	+ 13·0	11·01	26·0
3	− 1·57	+ 7·5	−13·51	−21·1
4	− 5·85	+ 0·9	15·92	16·0
5	− 9·27	− 5·9	18·24	10·8
6	−11·34	−11·7	20·44	− 5·4
7	−11·82	−15·8	22·52	+ 0·1
8	−10·62	−17·6	−24·45	5·6
9	− 7·94	−16·9	26·23	11·1
10	− 4·12	−13·7	27·85	16·6
11	+ 0·30	− 8·6	29·29	22·1
12	+ 4·69	− 2·2	30·55	27·5
13	+ 8·37	+ 4·6	−31·62	+32·7
14	+ 10·72	+ 10·5	32·49	37·8
15	+ 11·33	+ 14·7	33·16	42·7
16	+ 10·06	+ 16·4	33·62	47·4
17	+ 7·12	+ 15·3	33·88	51·8

Greenwich Noon. 1890.	Titan.		Iapetus.	
	$\alpha_s - A$	$\delta_s - D$	$\alpha_s - A$	$\delta_s - D$
Nov. 18	+ 3·00	+ 11″·7	− 33·92	+ 56″·0
19	− 1·63	+ 6·1	33·75	59·8
20	− 6·01	− 0·4	33·38	63·3
21	− 9·51	− 6·8	32·81	66·4
22	− 11·64	− 12·2	32·03	69·2
23	− 12·11	− 15·8	− 31·06	+ 71·5
24	− 10·88	− 17·2	29·90	73·4
25	− 8·11	− 16·1	28·56	74·9
26	− 4·18	− 12·7	27·04	76·0
27	+ 0·37	− 7·4	25·36	76·6
28	+ 4·87	− 1·0	− 23·52	+ 76·8
29	+ 8·63	+ 5·5	21·54	76·5
30	+ 11·09	+ 11·1	19·43	75·8
Dec. 1	+ 11·62	+ 14·9	17·20	74·6
2	+ 10·29	+ 16·1	14·86	73·0
3	+ 7·24	+ 14·7	− 12·42	+ 70·9
4	+ 2·99	+ 10·8	9·91	68·4
5	− 1·77	+ 5·2	7·33	65·5
6	− 6·26	− 1·3	4·70	62·2
7	− 9·84	− 7·6	− 2·03	58·5
8	− 11·99	− 12·7	+ 0·66	+ 54·5
9	− 12·44	− 16·0	3·35	50·1
10	− 11·13	− 17·1	6·04	45·3
11	− 8·25	− 15·7	8·71	40·3
12	− 4·18	− 12·1	11·33	35·1
13	+ 0·51	− 6·7	+ 13·90	+ 29·6
14	+ 5·13	− 0·3	16·41	23·9
15	+ 9·06	+ 6·2	18·83	18·0
16	+ 11·39	+ 11·7	21·14	12·0
17	+ 11·91	+ 15·2	23·35	+ 5·9
18	+ 10·50	+ 16·2	+ 25·43	− 0·3
19	+ 7·31	+ 14·5	27·37	6·5
20	+ 2·89	+ 10·5	29·15	12·7
21	− 2·00	+ 4·6	30·77	18·9
22	− 6·61	− 1·9	32·22	25·0
23	− 10·24	− 8·1	+ 33·48	− 30·9
24	− 12·39	− 13·3	34·54	36·7
25	− 12·78	− 16·5	35·40	42·3
26	− 11·35	− 17·4	36·05	47·6

Approximate Greenwich times of conjunctions of the satellites with the ends of the ring (*f* conj. with the *following*, *p* with the *preceding* end), "n," north, "s," south of the major axis of the ring. For Te., Di., Rh., the times of greatest elongations (e. east, w. west) are also given.

1890.		h				h				h	
Nov.	10	15·1	Rh. fs.	Nov.	18	17·0	Te. ps.	Nov.	26	22·3	Tit. sup. ☌
		16·2	En. fn.			20·9	Mi. fs.				s. 8″
		19·9	Te. w.			21·5	En. fn.		27	19·3	En. ps.
		20·6	Mi. pn.		19	0·0	Te. fs.			19·7	Te. w.
		21·2	Di. w.			14·8	Di. ps.			19·8	Mi. pn.
		22·6	En. pn.			15·6	Te. fn.			19·9	Di. ps.
		23·1	Tit. sup. ☌			16·0	Rh. fs.		28	16·3	Di. e.
			with centre, s. 9″			19·5	Mi. fs.			17·0	Rh. fs.
	11	13·7	Rh. e.			20·4	En. fs.			18·1	En. pn.
		15·0	En. fs.			22·6	Di. fs.			18·4	Te. e.
		17·5	Di. fs.			22·6	Te. pn.			23·8	Mi. ps.
		18·5	Te. e.		20	14·3	Te. ps.		29	2·2	Te. fn.
		19·3	Mi. pn.			14·7	Rh. e.			15·6	Rh. e.
	12	17·2	Te. w.			18·2	Mi. fs.			17·0	Te. w.
		17·5	En. ps.			21·3	Te. fs.			17·0	Mi. pn.
		17·9	Mi. pn.			22·9	En. ps.			20·6	En. fn.
		18·5	Di. fn.			23·6	Mi. fn.			22·4	Mi. ps.
		21·3	Rh. pn.			23·7	Di. fn.		30	0·9	Te. ps.
	13	14·9	Di. w.		21	13·3	Rh. fn.			1·1	Di. w.
		15·8	Te. e.			15·3	En. fn.			13·6	Di. ps.
		16·3	En. pn.			16·8	Mi. fs.			14·2	Rh. fn.
		16·5	Mi. pn.			19·9	Te. pn.			15·6	Mi. pn.
		19·9	Rh. w.			20·0	Di. w.			15·7	Te. e.
		21·9	Mi. ps.			21·7	En. pn.			19·5	En. fs.
		23·7	Te. fn.			22·2	Mi. fn.			21·0	Mi. ps.
	14	14·5	Te. w.			22·3	Rh. pn.			21·4	Di. fs.
		15·1	Mi. pn.		22	16·3	Di. fs.			23·2	Rh. pn.
		18·6	Rh. ps.			18·6	Te. fs.			23·5	Te. fn.
		18·9	En. fn.			20·8	Mi. fn.	Dec.	1	14·4	Te. w.
		20·5	Mi. ps.			20·9	Rh. w.			19·7	Mi. ps.
		22·3	Te. ps.		23	0·2	En. fn.			21·9	Rh. w.
		23·7	Di. e.			2·4	Te. e.			22·0	En ps.
	15	17·7	En. fs.			16·6	En. ps.			22·2	Te. ps.
		19·2	Mi. ps.			17·3	Te. pn.			22·5	Di. fn.
		20·0	Di. pn.			17·4	Di. fn.		2	13·0	Te. e.
		21·0	Te. fn.			19·4	Mi. fn.			14·4	En. fn.
	16	17·8	Mi. ps.			19·5	Rh. ps.			18·3	Mi. ps.
		19·7	Te. ps.			23·0	En. fs.			18·8	Di. w.
		20·2	En. ps.		24	13·7	Di. w.			20·5	Rh. ps.
		21·1	Di. ps.			15·5	En. pn.			20·8	En. pn.
		23·7	Mi. fs.			15·9	Te. fs.			20·8	Te. fn.
	17	0·7	Rh. fn.			18·0	Mi. fn.		3	11·7	Te. w.
		16·4	Mi. ps.			23·8	Te. e.			13·2	En. fs.
		17·4	Di. e.		25	14·6	Te. pn.			15·1	Di. fs.
		18·3	Te. fn.			16·7	Mi. fn.			16·9	Mi. ps.
		19·0	En. pn.			18·0	En. fn.			19·5	Te. ps.
		22·3	Mi. fs.			22·4	Te. w.		4	15·3	Tit. inf. ☌
	18	1·3	Te. pn.			22·6	Di. e.				n. 7″. Transit.
		13·8	Di. pn.		26	16·8	En. fn.			15·5	Mi. ps.
		15·0	Mi. ps.			18·9	Di. pn.			15·8	En. ps.
		15·8	Tit. inf. ☌			21·1	Te. e.			16·2	Di. fn.
			with centre, n. 8″			21·2	Mi. pn.			18·1	Te. fn.

1890.	h				h				h		
Dec. 4	21·4	Mi. fs.		Dec. 12	21·7	Mi. pn.		Dec. 20	11·4	Te. w.	
	22·1	En. fs.			22·2	Te. w.			13·8	Di. e.	
5	0·0	Di. fn.		13	13·0	Te. fs.			14·4	Tit. inf. ☌	
	12·5	Di. w.			13·5	En. fn.				n. 7″. Transit	
	14·1	Mi. ps.			14·4	Mi. fn.			16·0	Mi. ps.	
	14·6	En. pn.			17·6	Di. w.			16·3	En. pn.	
	16·8	Te. ps.			19·9	En. pn.			19·3	Te. ps.	
	20·0	Mi. fs.			20·3	Mi. pn.			21·9	Mi. fs.	
	23·8	Te. fs.			20·9	Te. e.			22·2	Rh. ps.	
6	15·4	Te. fn.		14	12·6	Rh. pn.		21	14·6	Mi. ps.	
	17·1	En. fn.			13·0	Mi. fn.			17·9	Te. fn.	
	18·7	Mi. fs.			13·9	Di. fs.			18·8	En. fn.	
	21·4	Di. e.			18·9	Mi. pn.			20·5	Mi. fs.	
	22·4	Te. pn.			19·5	Te. w.			22·7	Di. w.	
7	14·1	Te. ps.			22·4	En. fn.		22	0·9	Te. pn.	
	15·9	En. fs.		15	14·8	En. ps.			11·2	Di. ps.	
	17·3	Mi. fs.			15·0	Di. fn.			11·3	En. ps.	
	17·7	Di. pn.			17·5	Mi. pn.			13·3	Mi. ps.	
	17·9	Rh. fs.			18·2	Te. e.			16·6	Te. ps.	
	21·1	Te. fs.			21·2	En. fs.			17·6	En. fs.	
	22·7	Mi. fn.			22·8	Di. pn.			19·0	Di. fs.	
8	12·8	Te. fn.			22·9	Mi. ps.			19·2	Di. fs.	
	15·9	Mi. fs.		16	11·3	Di. w.			23·6	Te. fs.	
	16·6	Rh. e.			13·6	En. pn.		23	13·5	Rh. pn.	
	18·4	En. ps.			16·2	Mi. pn.			15·2	Te. fn.	
	18·7	Di. ps.			16·8	Te. w.			17·8	Mi. fs.	
	19·7	Te. pn.			18 8	Rh. fs.			20 0	Di. fn.	
	21·3	Mi. fn.			21·5	Mi. ps.			20·1	En. ps.	
9	15·1	Di. e.			23·7	En. ps.			22·2	Te. pn.	
	15·2	Rh. fn.			23·8	Di. ps.		24	12·1	Rh. w.	
	17·2	En. pn.		17	0·6	Te. ps.			12·6	En. fn.	
	18·4	Te. fs.			15·5	Te. e.			13·9	Te. ps.	
	19 9	Mi. fn.			16·2	En. fn.			16·3	Di. w.	
10	0·2	Rh. pn.			17·4	Rh. e.			16·4	Mi. fs.	
	17·1	Te. pn.			20·1	Di. e.			18·9	En. pn.	
	18·5	Mi. fn.			20·2	Mi. ps.			20·9	Te. fs.	
	19·7	En. fn.			22·5	En. pn.			21·8	Mi. fn.	
	22·8	Rh. w.			23·3	Te. fn.		25	12·5	Te. fn.	
	23·9	Di. w.		18	14·1	Te. w.			12·6	Di. fs.	
11	15·7	Te. fs.			15·0	En. fs.			15·0	Mi. fs.	
	17·2	Mi. fn.			16·0	Rh. fn.			19·5	Te. pn.	
	18·5	En. fs.			16·4	Di. pn.			19·7	Rh. fs.	
	20·1	Di. fs.			18·8	Mi. ps.			20·4	Mi. fn.	
	21·4	Rh. ps.			22·0	Te. ps.			21·5	En. ps.	
	23·1	Mi. pn.		19	12·8	Te. e.		26	13·7	Di. fn.	
	23·6	Te. e.			17·4	Mi. ps.			13·9	En. fn.	
12	14·4	Te. pn.			17·5	Di. ps.			18·2	Te. fs.	
	15·8	Mi. fn.			17·5	En. ps.			18·3	Rh. e.	
	21·1	En. ps.			20·6	Te. fn.			19·0	Mi. fn.	
	21·3	Di. fn.			23·3	Mi. fs.			20·3	En. pn.	
	21·6	Tit. sup. ☌			23·7	Rh. w.			21·5	Di. pn.	
		s. 7″. Occult.			23·8	En. fs.					

The rest of the ephemerides will be published in the next number of the *Monthly Notices*.

Ephemeris of the Satellite of Neptune, 1890–91.
By A. Marth.

Greenwich Noon.	P'	a	b	$u-U$	Diff.	U	B
1890.	°	″	″	°	°	°	°
Oct. 29	328·00	16·88	9·19	239·05	612·32	124·82	−32·96
Nov. 8	327·76	16·92	9·18	131·37	·29	125·10	32·87
18	327·50	16·95	9·17	23·66	·26	125·40	32·77
28	327·23	16·96	9·15	275·92	·27	125·72	32·66
Dec. 8	326·97	16·95	9·12	168·19	·27	126·01	32·55
18	326·72	16·92	9·07	60·46	·28	126·30	32·44
28	326·49	16·87	9·02	312·74	·31	126·57	32·34
1891. Jan. 7	326·30	16·81	8·97	205·05	612·35	126·79	−32·25
17	326·14	16·74	8·91	97·40	·40	126·97	32·18
27	326·04	16·65	8·85	349·80	·45	127·10	32·12
Feb. 6	325·98	16·56	8·80	242·25	·51	127·17	32·08
16	325·97	16·47	8·75	134·76	·57	127·18	32·07
26	326·01	16·37	8·70	27·33	·63	127·12	32·08
Mar. 8	326·11	16·28	8·65	279·96	·69	127·00	32·11
18	326·26	16·19	8·62	172·65	·75	126·82	32·17
28	326·45	16·11	8·59	65·40	612·81	126·59	32·24
Apr. 7	326·69	16·04	8·58	318·21		126·31	−32·33

Assumed value of N = 185°·20; of J = 119°·10.

The values of $u-U$, P', a and b are to be interpolated directly for the times for which the apparent positions of the satellite are required, and the position-angles p and distances s of the satellite are then found by means of the formulæ

$$s \sin (P'-p) = a \sin (u-U),$$
$$s \cos (P'-p) = b \cos (u-U).$$

The satellite moves in the direction of decreasing position-angles, and will be at its greatest elongations (*nf* in pos. P'+90°, *sp* in pos. P'−90° at distance a) and at its conjunctions (superior in pos. P', inferior in pos. P'−180° at distance b) about the following Greenwich times:—

1890.	h		1890.	h	1891.	h		1891.	h
Oct. 29	12·1	nf.	Dec. 3	18·8	Jan. 8	1·5	nf.	Feb. 12	7·9
30	23·4	sup.	5	6·1	9	12·7	sup.	13	19·2
Nov. 1	10·7	sp.	6	17·4	11	0·0	sp.	15	6·5
2	22·0	inf.	8	4·6	12	11·3	inf.	16	17·7
4	9·2	nf.	9	15·9	13	22·6	nf.	18	5·0
5	20·5	sup.	11	3·2	15	9·8	sup.	19	16·2
7	7·8	sp.	12	14·5	16	21·1	sp.	21	3·5
8	19·1	inf.	14	1·7	18	8·4	inf.	22	14·8
10	6·3	nf.	15	13·0	19	19·6	nf.	24	2·0
11	17·6	sup.	17	0·3	21	6·9	sup.	25	13·3
13	4·9	sp.	18	11·6	22	18·2	sp.	27	0·6
14	16·2	inf.	19	22·9	24	5·5	inf.	28	11·8
16	3·4	nf.	21	10·1	25	16·7	nf.	Mar. 1	23·1
17	14·7	sup.	22	21·4	27	4·0	sup.	3	10·3
19	2·0	sp.	24	8·7	28	15·3	sp.	4	21·6
20	13·3	inf.	25	20·0	30	2·5	inf.	6	8·8
22	0·6	nf.	27	7·2	31	13·8	nf.	7	20·1
23	11·8	sup.	28	18·5	Feb. 2	1·1	sup.	9	7·4
24	23·1	sp.	30	5·8	3	12·3	sp.	10	18·6
26	10·4	inf.	1891.		4	23·6	inf.	12	5·9
27	21·7	nf.	Jan. 2	4·4	6	10·9	nf.	13	17·1
29	9·0	sup.	3	15·6	7	22·1	sup.	15	4·4
30	20·2	sp.	5	2·9	9	9·4	sp.	16	15·6
Dec. 2	7·5	inf.	6	14·2	10	20·7	inf.	18	2·9

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APPENDIX.

LIST OF PRESENTS

RECEIVED DURING THE SESSION OF 1889-90,

AND OF

BOOKS PURCHASED WITH THE TURNOR, HORROX, AND LIBRARY FUNDS *

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APPENDIX TO VOL. L.

COMPARISON OF THE PLACES OF

THE MOON

DEDUCED FROM

BURCKHARDT'S AND HANSEN'S TABLES

FOR EVERY GREENWICH MEAN MIDNIGHT

DURING THE YEARS

1847–62

TOGETHER WITH A CORRECTED COMPARISON OF

HANSEN'S TABLES

WITH THE

GREENWICH OBSERVATIONS

DURING THE YEARS

1847–61

b
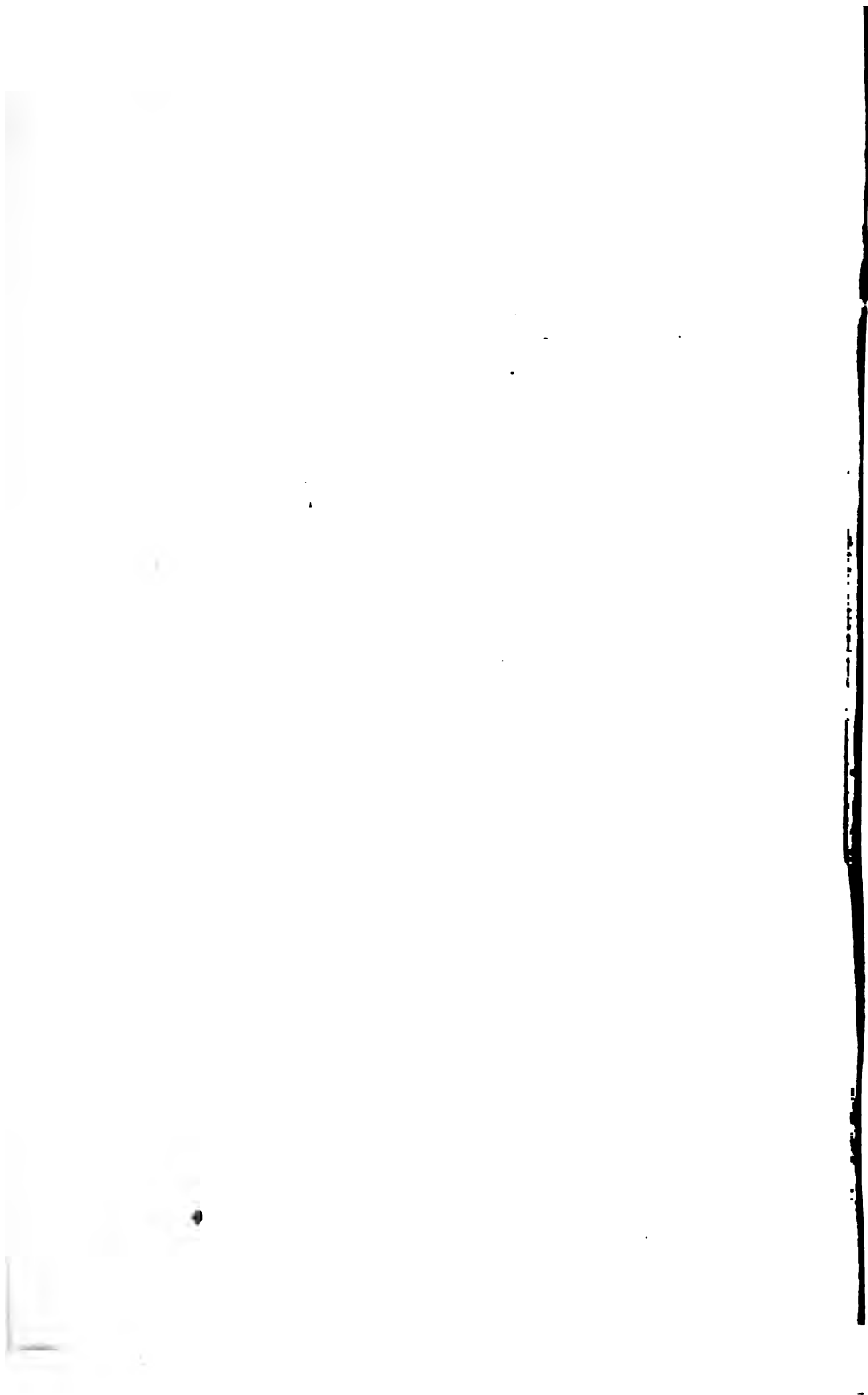
Comparison of the Places of the Moon deduced from Burckhardt's and Hansen's Tables for every Greenwich Mean Midnight during the Years 1847–62, together with a Corrected Comparison of Hansen's Tables with the Greenwich Observations during the years 1847–61. With some introductory remarks by Professor J. C. Adams, M.A., F.R.S.

In the *Greenwich Observations* for 1859, pp. 92–128, Sir George Airy has given a table showing the errors of the Moon's tabular places in longitude and ecliptic north polar distance, as deduced from the tables of Burckhardt and Hansen.

The original reductions of the Greenwich lunar observations for the years from 1847 to 1855 were vitiated by the use of Burckhardt's erroneous value of the Moon's parallax and consequent semidiameter, and accordingly, as Sir George has pointed out in his introductory remarks to the above-mentioned table, the Moon's right ascensions and north polar distances as deduced from observations on which these comparisons with the tables are founded, are not those which appear in the volumes of *Greenwich Observations* for the several years, but are the corrected values contained in the " Reduction of the Observations of the Moon from 1831 to 1851," and for the years 1852 to 1855, are those given in Addendum No. 1 to the Introduction to the *Greenwich Observations* for 1856.

By comparing the observed places thus corrected with the calculated places derived from the *Nautical Almanac* and founded on Burckhardt's tables, the apparent errors of those tables denoted in Sir George Airy's table by B – O are formed.

Sir George thus describes the further operation which he has employed in order to deduce the apparent errors of Hansen's tables from those of Burckhardt's which have been thus found :

" By the kindness of J. R. Hind, Esq., Superintendent of the *Nautical Almanac*, places of the Moon in longitude and latitude were computed, by the use of Hansen's ' Tables de la Lune,' for the midnight of every day on which the Moon had been observed with either instrument at the Royal Observatory, from 1847 to 1858. The comparison of these longitudes and latitudes with those of the *Nautical Almanac* gave at once the excess of Hansen's places over Burckhardt's, or H – B, for midnight of the day of observation; and this, it is conceived, may be adopted without sensible error for the time of observation, never distant more than a few hours. The algebraical addition of this H – B to B – O, found as is described above, gave the number H – O."

On this it should be remarked that the change of the quantity denoted by H – B in the course of a few hours is by no means always insensible. In fact the change of this quantity in 24

b 2

hours sometimes amounts to as much as 8″ or 9″, and therefore in six hours it may possibly amount to 2″.

Considering the precision of the observations themselves, and also that of Hansen's tables, it appeared to the Council that it would be well worth while to make the comparison between them more accurate by making the calculation of the differences H — B more complete. Accordingly, on the recommendation of the Council, and by the kindness of Mr. Hind, places of the Moon in longitude and latitude were computed by Hansen's tables for mean midnight of *every* day during the years for which the comparisons were wanted.

The expense of these computations has been met by means of a Government grant of 320*l*. from the Royal Society.

Knowing thus the value of H — B for every mean midnight, it was easy to derive by a simple interpolation the value of that quantity for the actual time of any observation, and thus to complete the determination of the apparent error of Hansen's tables.

The calculations have been extended to the end of the year 1861, after which date Hansen's tables are used in the *Nautical Almanac*, and are consequently directly compared with observation in the Greenwich reductions.

Hansen's lunar tables began to be used in the *Nautical Almanac* in the volume for 1862. The Moon's longitude and latitude having been previously obtained from Burckhardt's tables, a comparison of the Moon's places for Greenwich mean noon of every day in the year 1862, according to the two authorities, was given in pp. 543, 544 of the above volume.

The similar comparison contained in the tables now published is made for every day in the years 1847–61, but applies to the instant of Greenwich mean midnight instead of noon. As the calculations from Burckhardt's tables for 1862 had been originally made for midnight as well as for noon, Mr. Hind has been able kindly to supply the results of the comparisons for mean midnight in that year, so that these form a continuous series with the similar results given for the previous years.

Mr. Marth has called attention to two circumstances which slightly affect the comparison of the tabular place of the Moon with the place given by a meridian observation of that body, and which are not taken into account in the Greenwich reductions. First, there is a small correction required to the value of " The Sidereal Time at Mean Noon," given in the *Nautical Almanac*, and consequently to the mean solar time corresponding to a given sidereal time of observation. And, secondly, the Moon's motion in the interval between the predicted time of transit of the Moon's limb over the meridian and the observed time of that transit is neglected.

In order to find the true tabular error at the time of observation, the tabular place must of course be that which belongs to the true mean solar time of observation. But the tabular place

found from the *Nautical Almanac* is that which corresponds to the predicted sidereal time of transit when reduced to mean solar time by employing the sidereal time at mean noon given in the *Nautical Almanac*. Now this sidereal time, in those years with which we are here concerned, agrees with Bessel's determination made long since, and requires a sensible correction in order to bring it into accordance with the more recent solar tables of Le Verrier or Hansen.

Hence, if a denote the sidereal time of the observed transit of the Moon's bright limb over the meridian, or the right ascension of the Moon's bright limb at the actual time of transit; a_0 the predicted sidereal time of transit of the Moon's bright limb; and if μ be the correct sidereal time at mean noon; and μ_0 be the sidereal time at mean noon employed in the *Nautical Almanac*; then the actual mean solar time at the time of observation is the equivalent of $a - \mu$ sidereal time, whereas the predicted mean solar time of this transit, and therefore the time for which the Moon's place is given in the ephemeris, is the equivalent of $a_0 - \mu_0$ sidereal time.

Hence, if

$$a - \mu - (a_0 - \mu_0) = \tau,$$

that is, if

$$(a - a_0) - (\mu - \mu_0) = \tau.$$

the tabular place of the Moon ought to be corrected for the motion in τ sidereal seconds before being compared with the observed place.

The following little table gives the corrections of the *Nautical Almanac* values of " The Sidereal Time at Mean Noon " :

1840.	1850.	1860.	1870.
$+0^s\cdot452$	$+0^s\cdot493$	$+0^s\cdot533$	$+0^s\cdot573$

and the corresponding motion in the Moon's mean longitude in these sidereal times will be

1840.	1850.	1860.	1870.
$+0''\cdot248$	$+0''\cdot270$	$+0''\cdot292$	$+0''\cdot314$

The interpolation of the quantities $H-B$ for the times of observation and the calculation of Marth's corrections have been performed under the superintendence of the Astronomer Royal.

In Hansen's *Darlegung*, p. 439, the author has pointed out that in consequence of a term in the true longitude having been taken with a wrong sign, the tables require the following correction :

$$-0''\cdot62 \sin(2g - 4g' + 2\varpi - 4\varpi').$$

The argument of this equation expressed in Delaunay's notation is $4D - 2F$.

This correction has been taken into account in the computation of the Moon's places for the whole series of years 1847 to 1862.

Hansen's *Darlegung* was published in 1862. Professor Newcomb called explicit attention to the above-mentioned correction in 1878 in his "Investigation of Corrections to Hansen's Tables of the Moon;" and Mr. Hind states that the correction was introduced into the ordinary computations of the *Nautical Almanac* in the volume for 1883, which was the first occasion practicable after his receipt of Professor Newcomb's paper.

Of course the main value of the results now published arises from the fact that the Greenwich observations of the Moon, which had been before compared with Burckhardt's tables, have been here compared with those of Hansen, which, as regards the periodic inequalities at least, are far more accurate.

It is not without interest, however, to have so long a series of comparisons as are here given between the results of Burckhardt's tables and those of Hansen. The differences between them arise from the much greater number of periodic inequalities taken into account by Hansen, the more accurate determination of the coefficients of the periodic inequalities made by Hansen, and the differences between the values of the mean longitudes and the arguments of the larger periodic inequalities which are employed in the two sets of tables.

The following little table shows the corrections which must be applied to the mean longitude, the mean anomaly, and to the arguments of evection and of latitude employed in Burckhardt's tables, in order to make them agree with the corresponding arguments in the tables of Hansen:

	Mean Long.	Anomaly.	Argt. of Evection.	Argt. of Latitude.
1847	$+17''\!\cdot\!3$	$-16''\!\cdot\!7$	$+14''\!\cdot\!7$	$-18''\!\cdot\!2$
1848	$+17\cdot5$	$-16\cdot8$	$+14\cdot0$	$-19\cdot9$
1849	$+17\cdot5$	$-16\cdot7$	$+14\cdot4$	$-18\cdot6$
1850	$+17\cdot3$	$-16\cdot7$	$+13\cdot4$	$-19\cdot4$
1851	$+17\cdot5$	$-16\cdot7$	$+12\cdot5$	$-20\cdot4$
1852	$+17\cdot5$	$-16\cdot9$	$+12\cdot1$	$-20\cdot8$
1853	$+17\cdot5$	$-17\cdot0$	$+12\cdot1$	$-21\cdot4$
1854	$+17\cdot5$	$-17\cdot0$	$+11\cdot7$	$-22\cdot1$
1855	$+17\cdot6$	$-17\cdot2$	$+12\cdot3$	$-22\cdot7$
1856	$+17\cdot7$	$-17\cdot3$	$+11\cdot8$	$-23\cdot1$
1857	$+17\cdot4$	$-17\cdot5$	$+10\cdot8$	$-24\cdot0$
1858	$+17\cdot5$	$-17\cdot5$	$+11\cdot3$	$-24\cdot5$
1859	$+17\cdot6$	$-17\cdot6$	$+9\cdot9$	$-25\cdot0$
1860	$+17\cdot5$	$-17\cdot7$	$+9\cdot4$	$-25\cdot7$
1861	$+17\cdot3$	$-17\cdot9$	$+9\cdot4$	$-26\cdot5$
1862	$+17\cdot3$	$-17\cdot9$	$+8\cdot9$	$-27\cdot1$

DIFFERENCES

OF

LONGITUDE AND LATITUDE

GIVEN BY

BURCKHARDT'S AND HANSEN'S LUNAR TABLES

FOR EVERY GREENWICH MEAN MIDNIGHT

DURING THE YEARS

1847–62

HANSEN—BURCKHARDT.

1847. Day.	January. Long.	Lat.	February. Long.	Lat.	March. Long.	Lat.	April. Long.	Lat.	May. Long.	Lat.	June. Long.	Lat.
1	−1″.9	−0″.5	+0″.2	−4″.6	+2″.7	−7″.5	−4″.2	−7″.6	−5″.0	−4″.4	−7″.2	+0″.2
2	−2″.2	−2″.4	−0″.2	−4″.5	−0″.3	−7″.3	−6″.8	−7″.0	−7″.3	−3″.4	−8″.8	+1″.4
3	−1″.5	−3″.3	−0″.3	−4″.4	−2″.9	−6″.6	−8″.7	−6″.6	−8″.9	−2″.3	−10″.9	+3″.0
4	+0″.1	−4″.2	−0″.2	−4″.4	−4″.7	−6″.4	−9″.3	−6″.1	−9″.5	−1″.2	−11″.9	+4″.4
5	+1″.4	−4″.5	−0″.3	−4″.5	−4″.8	−6″.3	−9″.1	−5″.3	−10″.1	−0″.2	−11″.0	+6″.2
6	+1″.7	−4″.9	−1″.3	−4″.8	−4″.7	−6″.2	−7″.7	−4″.9	−10″.1	+0″.8	−7″.1	+7″.6
7	+0″.7	−5″.2	−2″.5	−5″.2	−4″.0	−5″.9	−5″.8	−3″.8	−9″.1	+2″.1	−1″.6	+8″.8
8	−1″.2	−5″.7	−3″.4	−5″.5	−3″.0	−5″.3	−2″.9	−2″.8	−5″.5	+3″.6	+4″.5	+9″.2
9	−3″.0	−6″.5	−3″.7	−5″.2	−2″.2	−5″.1	+1″.3	−1″.4	+0″.9	+4″.9	+8″.8	+9″.7
10	−4″.3	−7″.1	−3″.1	−4″.9	−0″.3	−4″.4	+6″.3	+0″.1	+7″.8	+6″.4	+10″.4	+9″.3
11	−5″.0	−7″.1	−2″.2	−3″.7	+2″.6	−3″.2	+10″.5	+1″.6	+13″.5	+7″.8	+9″.2	+8″.4
12	−5″.2	−6″.7	−2″.2	−2″.5	+5″.0	−1″.9	+12″.6	+3″.4	+15″.9	+8″.6	+5″.8	+7″.0
13	−6″.0	−5″.6	−5″.1	−0″.8	+6″.7	−0″.6	+10″.7	+5″.3	+14″.3	+9″.1	+1″.1	+5″.1
14	−8″.1	−4″.1	−10″.7	+0″.9	+5″.5	+0″.7	+6″.0	+6″.6	+9″.7	+8″.9	−3″.3	+3″.0
15	−12″.0	−2″.5	−17″.3	+2″.9	−0″.2	+2″.4	+0″.5	+7″.8	+5″.4	+7″.6	−6″.1	+0″.9
16	−16″.9	−0″.7	−21″.3	+4″.4	−8″.0	+4″.5	−3″.5	+7″.6	+1″.4	+5″.3	−7″.3	−1″.1
17	−20″.9	+0″.9	−20″.7	+5″.3	−13″.8	+6″.1	−5″.1	+6″.3	−0″.8	+3″.1	−7″.1	−3″.0
18	−21″.9	+2″.5	−16″.1	+5″.7	−16″.0	+6″.9	−4″.7	+4″.1	−2″.1	+0″.5	−6″.9	−4″.6
19	−19″.3	+3″.5	−10″.7	+5″.1	−14″.3	+6″.3	−3″.6	+1″.6	−3″.6	−1″.9	−7″.0	−6″.0
20	−13″.9	+4″.1	−7″.6	+4″.6	−10″.4	+5″.0	−3″.2	−0″.8	−5″.4	−4″.1	−6″.8	−7″.3
21	−9″.2	+4″.6	−6″.9	+3″.5	−7″.5	+3″.1	−5″.2	−3″.2	−7″.9	−6″.3	−6″.4	−8″.5
22	−6″.7	+5″.3	−7″.3	+1″.7	−6″.3	+0″.8	−8″.0	−5″.5	−10″.3	−8″.1	−5″.4	−9″.3
23	−6″.7	+5″.5	−6″.7	−0″.7	−6″.9	−1″.5	−10″.6	−7″.5	−11″.2	−9″.3	−4″.0	−9″.9
24	−7″.2	+5″.4	−4″.7	−3″.0	−7″.6	−4″.0	−11″.9	−8″.9	−10″.3	−10″.1	−3″.4	−9″.8
25	−6″.6	+4″.4	−1″.2	−5″.1	−7″.8	−6″.6	−11″.1	−9″.5	−7″.5	−10″.0	−3″.8	−9″.4
26	−4″.4	+2″.7	+1″.8	−6″.7	−6″.7	−8″.2	−8″.0	−9″.6	−3″.9	−9″.4	−5″.1	−8″.1
27	−0″.9	+0″.6	+4″.1	−7″.6	−4″.6	−9″.5	−4″.5	−8″.9	−1″.5	−8″.3	−7″.1	−6″.7
28	+2″.1	−1″.2	+4″.2	−7″.6	−1″.9	−9″.6	−1″.9	−7″.9	−1″.3	−6″.8	−8″.7	−4″.9
29	+3″.3	−2″.8	...	...	−0″.1	−9″.4	−1″.1	−6″.8	−2″.1	−4″.9	−9″.7	−3″.1
30	+2″.8	−3″.8	...	...	−0″.2	−9″.6	−2″.8	−5″.8	−3″.9	−3″.1	−10″.7	−1″.3
31	+1″.6	−4″.3	...	...	−1″.9	−8″.3	...	...	−5″.6	−1″.4	...	...

HANSEN—BURCKHARDT.

1847. Day.	July. Long.	Lat.	August. Long.	Lat.	September. Long.	Lat.	October. Long.	Lat.	November. Long.	Lat.	December. Long.	Lat.
1	−11.1	+0.5	−5.4	+2.9	−7.2	+2.1	−8.5	−2.2	−5.5	−7.0	−5.0	−8.9
2	−10.8	+2.4	−4.1	+3.9	−7.4	+0.5	−6.7	−3.9	−4.6	−7.3	−3.6	−8.3
3	−9.5	+4.2	−4.2	+3.9	−6.4	−1.7	−4.5	−5.1	−3.7	−7.2	−3.2	−7.5
4	−7.4	+5.6	−4.9	+3.4	−4.7	−3.5	−3.2	−5.8	−3.5	−6.6	−4.1	−6.8
5	−4.5	+6.9	−5.4	+1.9	−4.0	−4.8	−3.1	−5.9	−5.0	−5.8	−6.9	−5.7
6	−2.1	+7.2	−5.4	0.0	−5.1	−5.5	−4.5	−5.8	−8.6	−4.9	−11.8	−4.6
7	−0.6	+7.2	−6.1	−1.7	−8.3	−6.2	−7.5	−5.4	−13.7	−3.4	−17.2	−3.6
8	0.0	+6.3	−8.0	−3.1	−12.4	−6.1	−11.8	−4.7	−18.7	−2.3	−20.1	−2.5
9	−0.5	+5.0	−11.7	−4.1	−16.2	−5.9	−16.1	−3.8	−21.6	−1.1	−19.7	−2.0
10	−2.6	+3.3	−16.1	−4.7	−18.5	−5.0	−19.1	−2.5	−21.0	0.0	−16.3	−1.5
11	−6.2	+1.6	−19.2	−5.0	−18.7	−3.9	−20.3	−1.0	−17.1	+0.3	−11.9	−1.7
12	−10.6	+0.1	−19.6	−4.5	−16.7	−2.6	−19.2	+0.2	−12.0	+0.5	−8.7	−1.5
13	−13.9	−1.1	−17.4	−4.0	−14.2	−1.5	−16.7	+1.1	−7.6	+0.1	−7.3	−1.1
14	−15.1	−2.0	−13.6	−3.4	−12.1	−0.5	−13.3	+1.6	−6.0	−0.1	−7.5	−0.1
15	−14.2	−2.7	−9.7	−2.7	−11.1	+0.1	−10.3	+1.9	−6.6	0.0	−8.2	+1.2
16	−11.2	−3.1	−7.0	−2.5	−10.8	+0.5	−8.2	+1.5	−7.5	+1.0	−9.2	+2.6
17	−8.2	−3.7	−6.3	−2.5	−11.4	+0.7	−7.4	+1.6	−7.1	+2.0	−9.4	+3.7
18	−5.7	−4.5	−7.3	−2.7	−11.5	+0.8	−7.0	+1.9	−5.3	+3.0	−8.8	+3.5
19	−4.5	−5.3	−9.4	−3.0	−10.4	+0.9	−5.4	+2.2	−3.5	+3.7	−8.3	+3.0
20	−4.5	−6.5	−11.0	−3.2	−8.4	+1.2	−3.1	+3.0	−3.7	+4.2	−7.3	+2.1
21	−5.1	−7.4	−12.0	−3.2	−6.6	+1.6	−1.0	+3.6	−4.7	+4.0	−6.1	+1.2
22	−6.3	−7.9	−12.0	−3.3	−5.7	+2.3	−1.2	+4.5	−6.0	+3.0	−5.6	+0.3
23	−7.6	−8.1	−11.7	−3.0	−6.3	+3.0	−3.6	+5.0	−6.9	+1.6	−5.3	−0.7
24	−9.5	−8.2	−12.2	−2.2	−7.7	+4.1	−6.7	+5.1	−7.4	+0.3	−5.1	−1.8
25	−10.7	−7.5	−13.2	−1.4	−9.1	+4.9	−9.0	+4.0	−7.3	−1.6	−4.6	−2.7
26	−12.8	−6.3	−14.0	−0.3	−9.4	+5.1	−9.9	+2.5	−5.8	−3.5	−4.2	−3.6
27	−14.0	−5.1	−13.0	+1.0	−9.8	+4.6	−9.5	+0.8	−4.4	−4.5	−3.2	−4.9
28	−14.7	−3.6	−10.3	+2.3	−10.3	+3.4	−8.5	−1.2	−4.3	−5.7	−2.7	−5.6
29	−14.1	−1.9	−7.4	+3.3	−10.3	+1.9	−7.7	−3.2	−4.5	−7.0	−2.8	−6.5
30	−11.9	−0.1	−6.1	+3.7	−9.9	−0.2	−6.9	−4.8	−4.7	−7.8	−3.2	−6.7
31	−8.7	+1.3	−6.4	+3.2	...	...	−6.1	−6.0	...	...	−3.1	−6.9

Comparison of Burckhardt's and Hansen's

HANSEN—BURCKHARDT.

1848. Day.	January. Long.	Lat.	February. Long.	Lat.	March. Long.	Lat.	April. Long.	Lat.	May. Long.	Lat.	June. Long.	Lat.
1	-2.7	-6.1	-2.4	-3.2	$+3.8$	-2.7	$+7.5$	-0.8	$+12.6$	$+4.3$	$+3.3$	$+6.0$
2	-3.2	-5.6	-5.2	-2.5	$+2.7$	-2.4	$+3.0$	$+0.6$	$+7.7$	$+4.7$	-2.3	$+4.7$
3	-5.4	-4.8	-10.2	-1.8	-1.8	-1.7	-4.0	$+2.0$	$+1.0$	$+4.9$	-5.8	$+3.3$
4	-9.6	-4.1	-16.4	-0.7	-8.9	-0.5	-10.7	$+3.2$	-3.5	$+4.2$	-6.8	$+1.8$
5	-14.3	-3.3	-21.8	$+0.5$	-16.5	$+1.3$	-14.0	$+3.3$	-4.6	$+3.0$	-6.5	$+0.1$
6	-18.4	-2.6	-24.1	$+1.9$	-21.8	$+3.1$	-12.7	$+2.8$	-2.7	$+1.7$	-6.3	-1.6
7	-20.1	-1.6	-22.7	$+3.1$	-22.9	$+4.1$	-8.5	$+1.4$	-0.5	0.0	-6.5	-3.5
8	-19.3	-1.0	-18.2	$+4.0$	-19.5	$+4.3$	-4.6	-0.1	-0.4	-1.8	-7.5	-5.1
9	-16.5	-0.6	-13.6	$+4.5$	-14.6	$+3.7$	-2.9	-1.6	-2.5	-3.8	-8.6	-6.4
10	-12.9	$+0.7$	-10.9	$+4.5$	-10.8	$+2.5$	-3.9	-3.4	-5.9	-5.8	-9.2	-7.0
11	-9.8	$+1.6$	-10.9	$+3.7$	-9.4	$+0.8$	-6.0	-5.4	-8.3	-7.4	-8.7	-7.0
12	-8.4	$+2.7$	-12.2	$+2.3$	-9.4	-1.2	-7.3	-7.0	-9.3	-8.2	-6.7	-5.9
13	-9.1	$+3.2$	-12.7	$+0.2$	-9.4	-3.5	-7.7	-8.1	-8.4	-8.4	-4.2	-4.6
14	-10.6	$+3.6$	-11.3	-2.3	-8.4	-5.5	-6.5	-8.5	-6.1	-7.7	-1.9	-3.3
15	-12.0	$+2.9$	-7.9	-3.9	-6.4	-7.1	-4.8	-8.3	-3.6	-6.3	-1.0	-2.0
16	-11.9	$+1.5$	-4.8	-5.1	-4.4	-7.7	-3.6	-7.2	-2.0	-4.7	-1.6	-1.0
17	-9.5	$+0.5$	-3.0	-5.4	-3.2	-8.0	-3.5	-6.1	-1.8	-3.0	-3.5	$+0.2$
18	-6.6	-1.0	-3.3	-5.6	-3.3	-7.6	-4.4	-4.7	-2.7	-1.0	-5.3	$+0.8$
19	-4.6	-1.6	-4.4	-5.5	-4.0	-6.9	-5.7	-3.0	-4.4	$+0.4$	-7.2	$+1.7$
20	-4.3	-2.1	-4.9	-5.2	-4.7	-6.0	-6.8	-1.5	-6.0	$+1.7$	-9.2	$+2.6$
21	-5.2	-2.8	-4.3	-4.9	-5.3	-5.0	-7.5	-0.4	-7.4	$+2.5$	-11.1	$+3.9$
22	-5.7	-3.2	-3.0	-4.2	-5.3	-4.0	-7.5	$+0.6$	-8.6	$+3.5$	-12.1	$+5.1$
23	-5.0	-3.2	-1.9	-3.9	-5.1	-2.9	-7.0	$+1.2$	-9.6	$+4.0$	-11.6	$+6.6$
24	-3.4	-3.6	-1.6	-3.5	-4.6	-2.4	-6.5	$+1.6$	-10.2	$+5.0$	-8.8	$+7.1$
25	-2.1	-3.7	-2.1	-3.4	-4.4	-1.9	-5.4	$+1.6$	-9.2	$+5.9$	-3.6	$+7.0$
26	-1.7	-4.3	-2.5	-3.2	-3.5	-1.6	-3.5	$+1.6$	-5.8	$+6.9$	$+1.7$	$+6.5$
27	-2.1	-4.4	-1.6	-3.0	-2.0	-1.4	-0.2	$+1.9$	$+0.5$	$+7.4$	$+5.4$	$+5.1$
28	-2.6	-4.6	$+0.1$	-2.8	$+0.8$	-1.8	$+4.7$	$+2.5$	$+7.6$	$+7.7$	$+5.3$	$+3.7$
29	-2.9	-4.3	$+2.5$	-2.7	$+3.8$	-1.7	$+10.1$	$+3.0$	$+12.7$	$+7.7$	$+1.9$	$+2.6$
30	-2.1	-4.0	...	...	$+7.1$	-1.7	$+13.3$	$+3.7$	$+13.4$	$+7.3$	-3.8	$+.4$
31	-1.6	-3.4	...	...	$+8.9$	-1.6	...	...	$+9.6$	$+6.7$	...	...

HANSEN—BURCKHARDT.

1848. Day.	July. Long.	Lat.	August. Long.	Lat.	September. Long.	Lat.	October. Long.	Lat.	November. Long	Lat.	December. Long.	Lat.
1	−9.6	+0.5	−19.5	−6.2	−12.1	−3.2	−13.2	+1.7	−10.9	+4.0	−11.5	+0.4
2	−13.8	−0.5	−16.6	−5.2	−7.6	−1.4	−8.9	+3.0	−8.6	+4.1	−10.5	+0.8
3	−15.2	−1.5	−11.7	−4.0	−4.2	+0.3	−5.7	+3.7	−8.3	+4.1	−11.5	+2.0
4	−14.0	−2.3	−7.0	−2.7	−2.5	+1.4	−4.0	+3.9	−8.7	+4.4	−13.8	+2.6
5	−11.1	−2.8	−4.0	−1.7	−2.2	+2.2	−3.7	+4.3	−9.1	+5.1	−15.6	+3.4
6	−8.3	−3.2	−2.9	−0.8	−2.2	+2.4	−3.6	+4.3	−8.4	+5.4	−15.9	+3.1
7	−6.4	−3.7	−3.1	−0.1	−2.6	+2.8	−3.2	+4.5	−6.5	+5.5	−14.7	+2.4
8	−5.7	−4.0	−4.0	+0.5	−3.4	+2.7	−1.9	+4.5	−5.6	+4.8	−12.6	+0.8
9	−6.2	−3.6	−4.6	+1.0	−3.7	+2.7	−0.7	+4.5	−6.1	+3.8	−11.3	−0.6
10	−6.4	−2.8	−5.3	+0.8	−4.5	+2.4	−0.4	+4.2	−7.5	+2.4	−9.7	−1.5
11	−6.1	−2.5	−6.5	+0.6	−5.3	+2.2	−2.2	+4.1	−8.7	+0.8	−7.9	−2.7
12	−5.0	−1.8	−8.4	+0.4	−6.4	+2.2	−5.7	+3.7	−8.0	−0.8	−4.8	−2.8
13	−4.8	−1.4	−10.0	+0.1	−7.8	+2.0	−9.0	+2.5	−6.3	−2.5	−2.6	−4.5
14	−5.1	−1.3	−10.6	+0.3	−9.0	+2.4	−10.9	+1.3	−4.9	−4.5	−1.4	−5.6
15	−6.4	−1.0	−10.2	+0.4	−9.8	+2.2	−10.7	−0.1	−4.7	−6.2	−2.0	−6.8
16	−7.9	−1.0	−8.7	+0.7	−10.3	+1.8	−10.4	−1.8	−5.5	−8.2	−2.4	−7.7
17	−8.6	−0.4	−7.7	+1.6	−10.4	+1.4	−10.3	−3.6	−6.1	−9.7	−3.2	−7.7
18	−8.8	+0.3	−7.4	+2.0	−10.8	−0.2	−10.6	−5.4	−5.7	−10.8	−4.2	−7.6
19	−8.7	+1.3	−8.2	+2.5	−11.2	−1.6	−10.4	−7.2	−4.5	−11.0	−4.3	−6.7
20	−9.2	+2.7	−9.4	+1.8	−11.2	−3.2	−8.8	−8.5	−3.5	−10.4	−4.0	−5.2
21	−10.1	+3.6	−10.2	+0.5	−10.4	−5.0	−6.0	−9.0	−3.0	−9.0	−3.2	−3.6
22	−10.7	+4.2	−10.7	−1.5	−8.8	−6.7	−3.9	−9.2	−4.3	−7.3	−3.3	−2.2
23	−10.1	+3.7	−10.5	−3.4	−7.9	−7.7	−3.6	−8.6	−7.3	−5.2	−4.5	−1.4
24	−8.6	+2.3	−10.1	−5.6	−8.2	−8.4	−6.0	−7.7	−11.7	−3.2	−7.7	−0.7
25	−6.3	+0.7	−10.5	−7.2	−10.6	−8.4	−10.8	−6.3	−16.5	−1.6	−12.2	−0.9
26	−5.0	−1.4	−11.9	−8.6	−14.9	−7.7	−16.5	−4.4	−20.2	+0.2	−16.4	−1.2
27	−5.6	−3.4	−14.8	−9.1	−18.9	−6.6	−21.4	−2.1	−21.7	+1.0	−16.9	−1.0
28	−8.5	−4.8	−18.0	−9.2	−21.2	−4.5	−23.8	−0.2	−20.7	+1.6	−15.9	−1.6
29	−12.9	−5.9	−20.2	−8.6	−20.7	−2.4	−23.0	+1.9	−18.1	+1.2	−12.2	−1.5
30	−17.1	−6.4	−19.7	−7.2	−17.6	−0.4	−19.2	+3.1	−14.3	+0.9	−8.2	−2.2
31	−19.7	−6.6	−16.7	−5.6	...	...	−14.8	+4.0	...	...	−6.3	−1.3

Comparison of Burckhardt's and Hansen's

HANSEN—BURCKHARDT.

1849.	January.		February.		March.		April.		May.		June.	
Day.	Long.	Lat.	Long.	Lat.	Long.	Lat.	Long.	Lat.	Long.	Lat.	Long.	Lat.
1	−7.8	−0.5	−10.7	−1.3	−9.6	−0.5	−13.2	−6.4	−7.7	−8.8	−5.5	−4.4
2	−11.0	−0.1	−12.8	−2.9	−11.7	−2.2	−14.3	−7.9	−7.3	−8.7	−5.0	−2.7
3	−14.4	0.0	−13.7	−4.6	−14.3	−4.4	−13.1	−8.8	−5.8	−7.8	−3.9	−1.0
4	−15.8	−0.6	−14.0	−5.8	−16.0	−6.4	−9.5	−9.0	−4.7	−5.9	−3.1	+0.9
5	−15.2	−1.8	−13.9	−6.9	−15.4	−7.9	−6.2	−8.0	−4.3	−3.7	−2.8	+2.3
6	−14.4	−2.5	−13.6	−7.2	−12.9	−8.6	−4.4	−6.5	−4.6	−1.6	−2.9	+3.1
7	−13.3	−3.9	−13.1	−7.0	−10.1	−8.8	−3.9	−4.6	−4.7	+0.4	−3.3	+3.6
8	−12.7	−4.3	−12.5	−6.4	−7.7	−8.0	−4.3	−2.4	−4.3	+2.4	−3.9	+4.2
9	−12.4	−4.7	−11.6	−5.7	−7.0	−6.7	−4.2	−0.6	−3.3	+3.6	−4.7	+4.8
10	−11.2	−4.6	−10.4	−4.6	−7.1	−5.1	−3.6	+1.3	−3.0	+4.5	−5.6	+5.3
11	−9.2	−4.5	−9.2	−3.5	−7.1	−3.8	−2.9	+2.8	−2.5	+5.4	−6.3	+6.5
12	−6.9	−4.5	−8.2	−2.1	−6.7	−2.1	−2.8	+3.8	−3.2	+5.8	−6.9	+7.5
13	−5.5	−4.3	−7.8	−0.9	−6.3	−0.6	−3.3	+3.9	−4.5	+6.9	−6.7	+8.4
14	−5.2	−4.0	−7.3	+0.5	−5.9	+0.7	−3.8	+4.1	−4.6	+7.4	−5.2	+8.9
15	−5.5	−3.2	−6.6	+1.5	−5.8	+1.9	−3.2	+4.1	−2.6	+8.0	−2.6	+8.7
16	−5.9	−2.3	−4.3	+2.1	−5.4	+2.4	−0.4	+3.9	+0.6	+8.0	+1.3	+7.4
17	−6.0	−1.2	−1.2	+2.1	−3.3	+2.3	+4.6	+3.4	+5.2	+7.7	+3.5	+6.1
18	−4.5	+0.1	+1.9	+1.8	+0.4	+1.8	+9.4	+3.2	+9.6	+7.5	+2.1	+4.3
19	−2.2	+1.1	+3.3	+1.3	+4.5	+0.8	+13.3	+2.1	+11.0	+6.6	−3.8	+2.2
20	−0.1	+1.4	+2.2	+0.6	+7.3	0.0	+14.2	+1.3	+7.4	+5.5	−11.3	+0.4
21	+0.5	+1.4	−1.3	+0.2	+8.8	−0.7	+10.6	+0.7	+0.6	+3.7	−17.7	−1.4
22	−1.7	+1.0	−5.9	+0.5	+7.9	−1.0	+2.9	+0.3	−7.3	+1.9	−19.8	−2.8
23	−6.2	+0.8	−9.3	+0.7	+3.9	−1.0	−5.0	−0.9	−12.6	+0.1	−17.6	−3.9
24	−11.1	+0.4	−11.1	+0.9	−1.8	−0.9	−9.8	−1.8	−13.5	−1.4	−12.9	−4.4
25	−13.6	0.0	−11.3	+0.9	−8.0	−0.9	−10.0	−2.7	−10.9	−2.9	−8.7	−4.6
26	−13.0	−0.1	−10.4	+1.1	−11.6	−0.7	−7.3	−3.4	−7.3	−3.9	−6.1	−4.4
27	−10.0	−0.1	−9.1	+0.9	−11.7	−1.3	−4.5	−4.3	−4.5	−5.1	−5.7	−3.8
28	−6.8	0.0	−8.2	+0.6	−9.3	−1.8	−3.9	−5.3	−3.4	−6.2	−6.4	−2.9
29	−5.2	+0.2	...	...	−7.6	−2.4	−5.2	−6.4	−4.1	−7.4	−6.9	−1.4
30	−5.8	0.0	...	...	−7.6	−3.1	−7.0	−8.0	−4.9	−7.3	−6.3	+0.1
31	−8.1	−0.3	...	...	−10.2	−4.6	...	...	−5.6	−6.4	...	...

HANSEN—BURCKHARDT.

1849.	July.		August.		September.		October.		November.		December.	
Day.	Long.	Lat.	Long.	Lat.	Long.	Lat.	Long.	Lat.	Long.	Lat.	Long.	Lat.
1	−4.4	+1.6	−0.6	+5.0	−2.2	+4.1	−5.0	+4.8	−11.5	+1.0	−10.1	−3.7
2	−2.1	+2.7	−0.2	+4.3	−3.5	+3.7	−7.2	+3.5	−10.8	−1.3	−7.7	−5.7
3	−0.5	+3.2	−1.3	+3.7	−4.0	+3.1	−8.3	+1.8	−9.6	−3.6	−5.2	−7.8
4	−0.2	+3.4	−2.8	+3.2	−4.2	+2.4	−8.5	+0.9	−8.4	−5.6	−4.7	−9.9
5	−0.9	+3.3	−3.7	+3.0	−4.4	+1.9	−8.3	−0.5	−8.4	−8.0	−5.8	−11.5
6	−2.9	+3.2	−4.4	+2.6	−5.8	+1.6	−8.2	−1.5	−9.6	−10.1	−8.4	−12.3
7	−5.0	+3.1	−5.2	+2.4	−7.9	+1.0	−9.0	−2.9	−10.8	−12.2	−9.6	−12.0
8	−5.9	+3.4	−7.2	+2.5	−9.8	+0.2	−9.8	−4.5	−10.9	−13.1	−9.0	−10.6
9	−7.0	+3.7	−10.0	+2.1	−10.4	−1.2	−10.6	−6.1	−9.7	−13.0	−7.3	−8.2
10	−8.1	+4.1	−12.4	+1.5	−9.8	−3.0	−106	−8.1	−8.6	−12.0	−5.4	−5.8
11	−9.7	+4.9	−12.8	+0.1	−8.3	−5.2	−9.9	−9.8	−8.5	−10.0	−4.5	−3.5
12	−11.2	+5.0	−10.0	−1.9	−7.0	−7.5	−9.1	−10.5	−10.8	−7.7	−5.7	−1.8
13	−11.1	+4.4	−5.8	−4.0	−7.3	−9.4	−10.0	−10.6	−14.6	−5.4	−8.7	−0.2
14	−8.6	+3.1	−3.0	−6.4	−9.3	−11.1	−13.2	−10.0	−19.3	−2.7	−12.5	+0.8
15	−4.0	+1.2	−3.5	−8.5	−13.0	−12.0	−18.1	−8.2	−22.3	−0.7	−15.2	+1.3
16	−0.4	−0.9	−7.3	−10.4	−17.9	−12.3	−23.0	−6.2	−22.5	+1.0	−16.0	+1.3
17	−1.3	−3.3	−13.5	−11.8	−22.1	−10.8	−25.5	−4.0	−19.8	+2.2	−14.8	+1.2
18	−6.4	−5.5	−19.1	−12.9	−23.9	−9.1	−24.0	−1.3	−15.6	+2.9	−11.7	+0.8
19	−13.4	−6.8	−22.1	−12.6	−22.5	−6.5	−19.8	+0.6	−10.9	+3.4	−8.6	+0.5
20	−19.6	−7.9	−21.9	−11.1	−17.7	−3.4	−13.4	+2.1	−7.5	+3.7	−6.3	+0.8
21	−22.1	−8.2	−19.4	−8.8	−11.6	−1.3	−7.8	+2.9	−5.5	+4.2	−6.7	+1.0
22	−20.8	−8.1	−15.0	−6.0	−5.9	+0.4	−3.5	+3.8	−5.6	+5.2	−8.7	+1.8
23	−16.6	−7.0	−10.3	−3.4	−2.1	+1.8	−1.5	+4.5	−6.7	+6.0	−12.7	+2.1
24	−12.0	−5.4	−6.3	−1.1	−0.1	+2.9	−0.7	+5.5	−8.8	+6.9	−16.3	+1.7
25	−8.6	−3.6	−3.3	+1.2	+0.7	+3.7	−0.3	+6.3	−10.9	+6.9	−18.1	+1.1
26	−6.9	−1.6	−1.9	+2.6	+1.3	+4.5	−0.2	+7.1	−12.0	+6.2	−18.1	−0.5
27	−6.3	+0.4	−1.4	+4.0	+1.7	+5.0	−0.9	+7.7	−12.6	+4.7	−17.2	−1.9
28	−5.6	+2.2	−0.9	+4.7	+1.4	+5.5	−2.5	+7.9	−12.7	+2.8	−16.3	−3.5
29	−4.8	+3.9	−0.5	+4.9	0.0	+5.6	−5.1	+6.5	−12.7	+0.6	−15.5	−4.7
30	−3.3	+4.9	−0.3	+4.9	−2.5	+5.3	−8.0	+5.1	−12.1	−1.6	−13.4	−5.9
31	−1.6	+5.1	−1.0	+4.7	...	...	−10.5	+3.0	...	...	−10.3	−6.7

HANSEN—BURCKHARDT.

1850.	January.		February.		March.		April.		May.		June.	
Day.	Long.	Lat.	Long.	Lat.	Long.	Lat.	Long.	Lat.	Long.	Lat.	Long.	Lat.
1	−6.8	−7.3	−8.8	−3.3	−10.4	−4.6	−5.0	+0.6	−3.0	+3.9	+0.5	+6.7
2	−5.3	−7.9	−8.1	−1.4	−9.3	−2.5	−5.6	+2.1	−3.2	+5.1	+0.9	+7.8
3	−5.8	−8.0	−7.8	+0.9	−8.2	−0.2	−5.7	+3.8	−2.1	+6.4	+1.4	+8.6
4	−7.6	−6.4	−6.2	+2.9	−7.3	+1.7	−5.0	+4.7	+0.4	+7.3	+2.7	+9.1
5	−8.0	−5.0	−3.8	+4.5	−6.5	+3.4	−2.2	+5.1	+4.5	+7.7	+3.8	+8.9
6	−7.3	−2.7	−0.5	+5.5	−5.2	+4.4	+3.2	+5.0	+9.4	+7.7	+4.1	+8.4
7	−4.8	−0.8	+3.6	+5.4	−2.1	+4.9	+9.7	+4.5	+13.6	+7.2	+2.1	+7.5
8	−1.0	+1.2	+7.5	+5.2	+2.3	+4.8	+15.8	+3.8	+15.5	+6.8	−3.8	+6.1
9	+1.9	+2.4	+9.5	+4.7	+7.5	+4.2	+18.8	+26	+13.8	+5.6	−13.0	+4.0
10	+3.8	+2.8	+8.8	+4.0	+12.3	+3.4	+17.8	+1.9	+8.8	+4.1	−22.8	+1.5
11	+3.1	+3.1	+5.8	+3.2	+14.6	+2.4	+14.0	+1.1	+0.8	+2.7	−29.0	−1.3
12	−0.2	+2.8	+1.5	+2.7	+13.4	+2.0	+8.2	+0.4	−7.7	+0.9	−29.7	−3.6
13	−4.2	+2.3	−1.9	+2.2	+9.5	+1.6	+2.3	−0.6	−14.4	−0.7	−25.3	−5.4
14	−7.6	+1.9	−3.4	+1.8	+4.7	+0.9	−2.5	−1.4	−17.7	−2.7	−18.4	−6.6
15	−9.0	+1.1	−3.1	+1.2	+1.1	+0.7	−6.1	−1.9	−17.0	−4.7	−12.5	−6.9
16	−8.2	+0.5	−1.6	+0.8	−1.0	+0.5	−8.9	−2.7	−13.8	−6.5	−9.2	−7.0
17	−5.6	−0.1	−0.4	+0.8	−2.0	+0.5	−11.0	−3.9	−10.6	−8.3	−7.6	−5.9
18	−3.2	−0.6	−1.4	+0.3	−3.4	+0.3	−12.9	−5.4	−9.4	−9.1	−6.9	−4.3
19	−2.4	−0.7	−4.3	−0.2	−5.7	−0.1	−14.6	−7.1	−9.8	−9.5	−6.0	−2.8
20	−3.9	−0.8	−8.6	−1.4	−9.3	−1.3	−16.0	−9.2	−10.6	−9.4	−4.8	−1.1
21	−6.9	−1.2	−12.5	−3.3	−13.7	−3.0	−16.2	−10.5	−10.1	−8.2	−4.1	+0.4
22	−10.8	−1.7	−15.2	−5.3	−16.9	−5.3	−14.4	−11.4	−8.9	−6.2	−4.3	+1.3
23	−14.5	−2.6	−16.4	−7.4	−17.8	−7.8	−11.1	−10.1	−6.9	−4.5	−4.5	+2.4
24	−16.6	−4.0	−16.1	−9.1	−15.8	−9.7	−7.2	−8.7	−5.3	−2.6	−5.2	+2.7
25	−17.5	−5.4	−15.6	−9.8	−12.8	−10.7	−4.0	−6.7	−5.1	−1.1	−5.0	+2.6
26	−18.5	−6.8	−14.9	−9.7	−9.4	−10.5	−2.6	−4.8	−5.4	+0.4	−3.6	+2.4
27	−19.2	−7.7	−13.7	−8.6	−6.6	−9.4	−2.3	−3.0	−4.7	+1.3	−1.8	+2.6
28	−18.3	−8.2	−11.9	−6.8	−5.3	−7.6	−2.6	−0.7	−3.6	+2.4	−0.3	+2.8
29	−16.2	−7.7	...	...	−4.8	−5.6	−2.8	+0.9	−2.1	+2.9	+0.3	+3.1
30	−13.3	−6.9	...	...	−5.2	−3.7	−2.9	+2.6	−0.8	+4.4	−1.1	+4.3
31	−10.5	−5.3	...	...	−5.2	−1.5	...	..	+0.1	+5.4	...	...

HANSEN—BURCKHARDT.

1850. Day.	July. Long.	Lat.	August. Long.	Lat.	September. Long.	Lat.	October. Long.	Lat.	November. Long.	Lat.	December. Long.	Lat.
1	−3.5	+4.3	−10.5	+0.4	−7.4	−4.0	−6.8	−7.2	−15.5	−6.9	−12.0	−2.0
2	−5.4	+4.9	−8.9	−0.3	−4.0	−5.8	−6.9	−8.4	−18.0	−5.2	−12.6	0.0
3	−6.2	+5.1	−6.3	−1.3	−3.1	−8.0	−11.1	−9.0	−21.4	−3.1	−14.8	+1.5
4	−5.5	+5.0	−4.6	−2.7	−7.5	−10.1	−18.3	−9.1	−24.7	−1.3	−16.8	+2.6
5	−4.6	+4.3	−6.0	−4.7	−15.8	−11.9	−25.7	−7.9	−25.8	0.0	−16.8	+3.0
6	−5.3	+3.2	−11.6	−7.0	−24.9	−12.5	−30.8	−6.9	−24.3	+1.5	−13.8	+3.3
7	−9.4	+1.7	−19.3	−9.4	−31.0	−12.0	−31.7	−5.1	−20.0	+2.5	−9.3	+3.1
8	−17.6	−0.9	−26.5	−11.2	−32.2	−10.5	−29.0	−3.4	−13.8	+3.3	−4.4	+3.0
9	−26.6	−3.4	−30.4	−11.5	−28.6	−8.4	−23.3	−1.8	−7.7	+4.0	−1.3	+2.9
10	−32.6	−5.6	−29.7	−10.5	−22.0	−6.4	−16.7	−0.4	−3.2	+4.3	−0.8	+2.6
11	−32.9	−7.3	−25.4	−8.7	−15.3	−4.3	−10.3	+0.6	−1.2	+4.9	−1.9	+2.8
12	−28.9	−7.7	−19.5	−6.5	−9.4	−2.4	−5.5	+1.9	−0.8	+5.5	−4.5	+2.8
13	−22.5	−7.1	−13.8	−4.3	−6.0	−0.7	−2.8	+3.0	−2.0	+5.9	−7.3	+2.7
14	−16.7	−6.0	−9.1	−2.3	−4.1	+0.9	−1.8	+4.2	−4.0	+5.9	−10.0	+2.2
15	−12.0	−4.3	−6.2	−0.1	−2.7	+2.1	−1.6	+4.9	−6.7	+5.9	−12.0	+1.8
16	−8.7	−2.1	−3.9	+1.4	−1.8	+3.3	−2.4	+5.4	−9.8	+5.1	−13.8	+0.7
17	−6.4	−0.1	−2.3	+2.9	−0.8	+3.7	−4.1	+5.5	−12.9	+4.2	−15.3	−0.4
18	−4.0	+1.5	−0.5	+3.5	−0.2	+3.7	−7.0	+4.9	−14.9	+2.8	−16.9	−1.9
19	−2.4	+2.9	+0.9	+3.8	−1.6	+3.6	−10.5	+4.4	−15.8	+1.2	−17.9	−3.4
20	−1.4	+3.7	+2.0	+3.8	−4.1	+3.2	−13.3	+3.2	−15.2	−0.6	−17.4	−5.1
21	−0.7	+4.0	+1.6	+3.4	−7.3	+2.3	−14.1	+2.2	−14.0	−2.5	−15.6	−7.2
22	−0.6	+3.9	+0.4	+2.8	−9.1	+1.7	−12.7	+0.6	−12.5	−5.0	−14.1	−8.7
23	−1.1	+3.7	−1.8	+2.0	−9.2	+0.8	−10.2	−0.7	−11.7	−7.3	−14.5	−9.6
24	−1.2	+3.1	−3.9	+1.4	−7.9	+0.1	−8.2	−1.8	−12.2	−9.8	−16.4	−9.5
25	−1.6	+2.5	−5.7	+0.7	−6.8	+0.1	−8.5	−3.2	−14.0	−11.3	−19.0	−8.6
26	−1.8	+1.8	−7.1	+0.3	−7.3	−0.2	−10.0	−5.3	−16.3	−12.0	−19.5	−6.5
27	−2.3	+1.4	−8.1	+0.1	−9.5	−1.0	−12.0	−7.1	−18.2	−11.2	−17.1	−3.7
28	−3.9	+1.0	−9.3	0.0	−11.3	−2.6	−13.3	−8.7	−18.3	−9.5	−12.1	−1.2
29	−6.1	+1.0	−10.9	−0.3	−11.2	−4.1	−13.1	−9.6	−16.3	−7.0	−6.3	+0.9
30	−8.2	+1.0	−11.4	−1.0	−9.3	−5.7	−12.9	−9.2	−13.4	−4.2	−2.7	+2.6
31	−10.2	+0.9	−10.2	−2.3	...	...	−13.9	−8.4	...	...	−1.9	+3.2

Comparison of Burckhardt's and Hansen's

HANSEN—BURCKHARDT.

1851. Day.	January. Long.	Lat.	February. Long.	Lat.	March. Long.	Lat.	April. Long.	Lat.	May. Long.	Lat.	June. Long.	Lat.
1	−3″7	+3″4	+3″2	+3″9	+16″8	+4″2	+14″2	+1″3	+5″3	+1″2	−21″1	−1″0
2	−6·3	+3·7	+0·2	+3·1	+13·1	+3·4	+8·0	+0·5	−1·4	+0·4	−23·5	−2·8
3	−7·9	+3·6	−1·0	+1·9	+8·4	+2·3	+2·4	+0·2	−7·5	−1·0	−22·7	−4·6
4	−7·5	+2·7	−2·1	+0·8	+3·5	+1·7	−2·1	0·0	−11·6	−2·4	−20·4	−6·3
5	−5·6	+1·6	−1·7	−0·1	0·0	+1·1	−5·4	−0·5	−14·5	−3·8	−17·6	−6·9
6	−2·7	+0·6	−1·1	−0·6	−1·7	+0·7	−8·2	−1·0	−16·3	−5·6	−15·1	−6·9
7	−1·5	−0·2	−1·2	−0·9	−2·2	+0·7	−11·9	−1·6	−17·5	−7·3	−14·6	−5·9
8	−1·6	−0·7	−3·1	−1·0	−3·1	+0·5	−15·5	−3·4	−18·2	−8·7	−14·2	−4·5
9	−2·6	−1·1	−6·6	−1·4	−5·4	+0·6	−18·4	−5·7	−18·5	−9·4	−13·6	−2·7
10	−5·2	−1·5	−11·1	−2·3	−9·2	−0·2	−19·5	−7·7	−17·9	−9·1	−12·1	−1·1
11	−8·4	−1·6	−15·5	−3·2	−14·0	−2·0	−18·6	−9·4	−16·4	−8·2	−10·6	+0·4
12	−12·0	−1·8	−18·5	−4·8	−17·3	−4·2	−16·3	−10·0	−13·6	−6·8	−9·6	+1·0
13	−14·8	−2·6	−20·2	−6·1	−18·3	−6·3	−13·5	−9·8	−11·1	−5·3	−9·3	+1·3
14	−17·4	−3·2	−20·4	−7·1	−16·9	−8·2	−11·1	−9·2	−9·2	−4·2	−9·0	+1·5
15	−18·9	−4·2	−20·5	−7·9	−16·0	−9·0	−9·2	−7·8	−8·6	−3·0	−7·9	+1·6
16	−20·5	−5·2	−20·0	−7·6	−15·1	−9·0	−8·2	−6·6	−8·5	−1·8	−5·8	+1·3
17	−21·1	−6·5	−18·1	−6·6	−14·4	−8·4	−7·8	−5·2	−9·6	−0·7	−3·1	+1·1
18	−20·6	−7·2	−14·8	−5·4	−12·9	−7·1	−7·1	−3·4	−8·0	+0·5	−1·2	+1·0
19	−18·7	−7·4	−10·8	−3·3	−10·2	−5·5	−6·7	−1·5	−6·3	+1·8	−0·5	+0·9
20	−16·3	−6·7	−7·7	−0·9	−6·8	−3·6	−6·0	+0·5	−4·7	+3·0	−0·8	+0·9
21	−14·5	−5·3	−5·7	+1·1	−4·2	−1·8	−4·8	+2·3	−3·1	+4·2	−2·0	+1·0
22	−14·0	−3·9	−4·5	+3·1	−3·3	+0·4	−3·8	+4·2	−2·2	+4·8	−2·0	+1·1
23	−13·9	−1·5	−2·7	+5·0	−2·8	+2·3	−1·3	+5·4	−0·8	+5·0	−1·8	+1·4
24	−12·5	+0·9	+0·4	+6·2	−2·1	+3·4	+1·1	+5·9	+1·4	+4·9	−1·6	+1·9
25	−9·2	+2·9	+4·9	+6·4	−0·2	+5·1	+5·7	+5·4	+4·0	+4·4	−2·9	+2·0
26	−5·0	+4·9	+10·3	+6·6	+3·8	+5·3	+10·6	+5·0	+6·5	+4·3	−6·6	+2·2
27	+1·5	+6·0	+15·0	+6·2	+9·0	+5·4	+14·9	+4·2	+7·1	+3·9	−13·1	+1·9
28	+6·2	+6·4	+17·5	+5·2	+14·7	+5·1	+17·2	+3·2	+4·4	+3·9	−20·9	+0·5
29	+8·6	+6·4	...	...	+19·2	+3·1	+16·1	+2·6	−1·1	+3·3	−28·3	−1·1
30	+8·7	+5 8	...	...	+20·8	+2·8	+11·4	+1·9	−8·4	+2·2	−33·5	−2·6
31	+6·7	+5·0	...	...	+18·7	+2·5	...	...	−15·8	+0·9	...	...

HANSEN—BURCKHARDT.

1851. Day.	July. Long.	Lat.	August. Long.	Lat.	September. Long.	Lat.	October. Long.	Lat.	November. Long.	Lat.	December. Long.	Lat.
1	−34.6	−4.2	−29.6	−5.3	−17.0	−2.9	−11.1	+1.6	−4.6	+4.4	−4.8	+0.7
2	−31.9	−4.9	−22.1	−4.2	−11.6	−1.7	−7.2	+2.6	−5.9	+3.6	−6.5	−0.5
3	−26.4	−5.1	−15.6	−2.9	−7.3	−0.2	−5.0	+3.0	−7.6	+2.5	−7.6	−1.6
4	−19.9	−4.5	−10.7	−1.5	−4.9	+0.8	−4.3	+3.0	−9.1	+1.4	−8.7	−2.4
5	−14.9	−3.5	−7.6	−0.1	−2.9	+1.8	−5.5	+2.6	−10.0	+0.1	−9.4	−2.9
6	−11.6	−1.9	−5.4	+1.0	−2.1	+1.9	−7.7	+1.7	−11.1	−1.0	−11.4	−3.0
7	−9.9	−0.6	−3.7	+2.3	−2.4	+2.0	−8.5	+0.8	−12.7	−1.6	−13.1	−3.1
8	−8.6	+1.1	−3.1	+2.8	−4.3	+1.1	−10.2	−0.5	−14.4	−2.6	−14.5	−3.2
9	−8.2	+2.3	−3.3	+3.0	−6.9	+0.6	−12.2	−1.6	−15.3	−3.0	−13.9	−3.7
10	−7.4	+3.3	−4.4	+2.7	−9.2	−0.7	−13.5	−2.5	−14.3	−2.6	−11.7	−4.3
11	−7.3	+3.4	−5.6	+1.8	−10.1	−1.9	−13.9	−2.8	−11.7	−3.1	−9.6	−4.9
12	−7.4	+3.4	−6.0	+0.6	−9.4	−2.7	−13.0	−3.2	−8.7	−3.8	−9.9	−5.9
13	−7.0	+2.8	−5.3	−1.0	−8.0	−3.2	−11.1	−3.0	−8.0	−4.8	−12.4	−6.5
14	−5.7	+1.6	−3.9	−2.0	−7.0	−3.4	−9.4	−3.4	−9.9	−6.5	−16.3	−6.5
15	−3.5	+0.6	−2.1	−2.8	−6.8	−3.3	−9.4	−3.9	−13.7	−7.5	−19.2	−5.3
16	−0.9	−0.7	−1.5	−3.2	−8.4	−3.2	−11.5	−5.0	−17.2	−7.6	−19.5	−3.5
17	+0.6	−1.6	−2.4	−3.5	−11.2	−3.9	−14.3	−6.3	−18.5	−6.4	−17.2	−0.8
18	+0.9	−2.2	−4.6	−3.4	−13.3	−4.8	−16.6	−7.2	−17.1	−4.3	−13.2	+1.6
19	−0.3	−2.3	−7.3	−3.6	−14.3	−6.0	−17.1	−7.3	−14.4	−1.7	−9.5	+3.6
20	−2.4	−2.3	−9.4	−4.0	−13.5	−7.0	−16.7	−6.7	−13.2	+0.4	−6.8	+5.2
21	−4.4	−2.2	−10.1	−4.2	−12.2	−7.3	−16.4	−5.1	−14.0	+2.7	−5.8	+6.0
22	−5.8	−1.8	−9.5	−5.2	−13.2	−7.6	−18.4	−3.4	−16.8	+4.4	−6.4	+6.6
23	−6.7	−1.6	−8.8	−5.7	−18.6	−7.4	−23.4	−1.6	−19.3	+5.5	−7.3	+6.4
24	−7.5	−1.6	−11.0	−6.7	−27.7	−6.9	−28.9	+0.2	−19.9	+6.3	−7.6	+5.7
25	−9.4	−1.8	−17.9	−7.6	−35.7	−5.8	−32.6	+1.8	−17.6	+6.1	−6.4	+4.4
26	−14.0	−2.4	−27.8	−8.5	−40.0	−4.4	−32.0	+3.2	−13.4	+6.0	−4.0	+2.6
27	−21.3	−3.6	−36.2	−8.4	−38.9	−2.7	−27.7	+4.2	−8.6	+5.1	−2.3	+0.9
28	−29.8	−5.0	−40.3	−7.7	−32.7	−1.6	−20.9	+4.7	−5.0	+4.3	−2.2	−0.3
29	−36.8	−6.0	−38.3	−6.8	−24.9	−0.3	−13.7	+4.8	−2.8	+3.1	−2.4	−1.9
30	−39.7	−6.4	−31.8	−5.4	−17.3	+0.6	−8.1	+5.2	−3.3	+1.8	−3.8	−2.8
31	−36.5	−6.1	−24.2	−4.1	...	...	−5.3	+4.9	...	...	−5.4	−3.8

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HANSEN—BURCKHARDT.

1852.	January.		February.		March.		April.		May.		June.	
Day.	Long.	Lat.	Long.	Lat.	Long.	Lat.	Long.	Lat.	Long.	Lat.	Long.	Lat.
1	−6″7	−4″7	−11″7	−6″3	−13″1	−6″3	−13″2	−8″1	−12″6	−5″4	−12″5	+2″6
2	−7·9	−5·1	−12·6	−6·7	−12·6	−6·9	−12·6	−7·0	−12·3	−3·8	−12·7	+3·2
3	−9·4	−5·5	−13·1	−6·5	−12·3	−6·9	−12·8	−5·6	−13·2	−2·2	−11·1	+3·1
4	−11·4	−5·5	−14·1	−6·2	−13·1	−6·1	−12·7	−3·8	−14·2	−1·0	−9·3	+3·0
5	−12·9	−5·8	−16·1	−5·5	−14·3	−4·7	−12·6	−2·1	−13·3	+0·2	−6·9	+2·4
6	−14·4	−5·8	−17·4	−4·5	−15·2	−3·1	−10·6	−0·8	−10·5	+1·0	−5·4	+1·8
7	−15·1	−5·9	−17·1	−3·1	−13·7	−1·2	−7·3	+0·7	−7·0	+1·5	−4·5	+0·4
8	−15·3	−5·5	−15·8	−1·5	−10·6	−0·2	−3·8	+1·9	−3·5	+2·3	−4·2	−1·0
9	−15·1	−5·3	−13·2	0·0	−7·0	+1·4	−1·1	+3·4	−1·8	+2·5	−3·9	−2·2
10	−15·9	−4·7	−11·6	+1·5	−4·4	+2·9	+0·7	+4·4	−1·4	+2·4	−3·0	−3·3
11	−16·8	−3·7	−11·1	+3·4	−3·1	+4·1	+2·3	+5·1	−1·0	+1·5	−1·3	−3·9
12	−18·1	−2·5	−10·4	+5·5	−1·9	+5·9	+4·5	+5·0	+0·2	+0·5	+0·6	−4·1
13	−18·6	−0·7	−7·9	+7·1	−0·2	+7·1	+7·2	+4·0	+2·9	−0·8	+2·5	−3·9
14	−18·3	+1·7	−3·0	+8·6	+4·6	+7·1	+10·6	+2·6	+6·3	−1·9	+2·9	−3·1
15	−15·9	+3·9	+4·1	+8·8	+10·0	+7·1	+14·1	+1·0	+9·4	−2·5	+0·8	−2·6
16	−11·3	+6·2	+10·9	+8·4	+14·9	+6·1	+16·5	−0·3	+10·6	−2·5	−3·8	−2·0
17	−5·0	+7·5	+14·7	+7·3	+18·2	+4·4	+16·7	−1·3	+8·8	−2·2	−9·1	−2·1
18	+0·9	+8·1	+15·0	+6·0	+18·8	+2·3	+13·9	−1·8	+4·3	−2·2	−14·2	−2·0
19	+4·6	+8·1	+12·3	+4·1	+17·3	+1·2	+9·1	−2·2	−2·1	−2·3	−17·3	−2·6
20	+5·6	+7·5	+8·4	+2·6	+13·8	+0·2	+2·8	−2·5	−7·8	−2·2	−18·9	−2·8
21	+3·7	+6·7	+4·9	+1·2	+9·2	−1·1	−2·9	−2·9	−11·7	−3·0	−19·6	−3·0
22	+1·1	+4·9	+3·0	−0·2	+4·6	−1·6	−7·1	−3·4	−13·4	−4·0	−19·2	−2·8
23	−0·5	+3·1	+2·0	−1·2	+1·0	−2·0	−9·5	−4·0	−14·0	−4·6	−18·0	−2·5
24	−0·5	+1·2	+0·6	−1·8	−2·3	−2·2	−10·3	−4·7	−14·2	−5·4	−16·0	−1·7
25	−0·1	−0·5	−1·4	−2·4	−4·6	−2·5	−11·4	−5·8	−15·2	−5·5	−13·9	−0·3
26	−0·1	−2·1	−4·2	−2·8	−7·1	−3·0	−12·3	−7·2	−16·0	−5·5	−11·9	+1·2
27	−1·2	−3·1	−7·2	−3·1	−9·2	−3·9	−14·1	−8·0	−15·9	−4·6	−10·8	+2·8
28	−3·1	−3·6	−10·1	−4·1	−11·1	−4·9	−15·3	−8·2	−14·5	−3·1	−10·2	+4·4
29	−5·7	−5·0	−12·1	−5·2	−12·4	−6·6	−15·5	−8·2	−12·7	−1·5	−9·6	+5·8
30	−8·4	−5·1	...	...	−13·7	−7·7	−14·2	−7·0	−11·6	−0·1	−8·5	+6·2
31	−10·4	−5·3	...	...	−13·8	−8·2	...	...	−11·3	+1·5	...	...

HANSEN—BURCKHARDT.

1852. Day	July. Long. Lat.		August. Long. Lat.		September. Long. Lat.		October. Long. Lat.		November. Long. Lat.		December. Long. Lat.	
1	$-7''8$	$+6''0$	$-9''7$	$+3''0$	$-7''3$	$-1''7$	$-6''3$	$-3''6$	$-5''5$	$-4''4$	$-5''9$	$-3''8$
2	-6.9	$+5.2$	-8.1	$+1.2$	-3.0	-2.2	-3.1	-3.9	-5.8	-5.3	-7.3	-4.3
3	-6.3	$+4.0$	-4.8	-0.5	0.0	-2.5	-2.2	-4.3	-8.8	-6.0	-10.3	-4.1
4	-5.6	$+2.1$	-1.5	-1.7	$+0.5$	-2.9	-3.8	-5.3	-13.2	-6.8	-13.0	-3.6
5	-4.6	0.0	$+0.3$	-2.6	-1.3	-4.0	-6.9	-6.7	-17.4	-6.8	-13.2	-2.3
6	-3.3	-1.4	$+0.4$	-3.1	-3.8	-5.2	-11.7	-8.4	-19.4	-5.9	-10.5	-0.6
7	-2.5	-2.6	-0.6	-3.8	-6.7	-6.7	-15.8	-9.6	-18.6	-4.4	-6.8	$+1.4$
8	-1.9	-3.7	-2.1	-4.3	-8.8	-8.0	-18.6	-9.5	-17.0	-2.3	-4.3	$+3.2$
9	-2.1	-4.6	-2.6	-5.1	-10.6	-9.0	-20.8	-8.7	-16.7	-0.2	-4.6	$+5.3$
10	-2.0	-4.7	-3.0	-5.5	-13.9	-9.5	-23.0	-7.2	-19.6	$+2.4$	-7.3	$+7.1$
11	-1.4	-4.8	-4.4	-6.2	-20.0	-9.3	-27.3	-5.3	-24.0	$+5.1$	-10.1	$+8.3$
12	-1.1	-4.5	-7.6	-6.7	-27.8	-8.4	-33.4	-3.0	-27.1	$+6.9$	-11.6	$+8.4$
13	-1.9	-4.4	-13.7	-7.0	-37.3	-7.2	-39.1	-0.5	-26.1	$+8.3$	-11.5	$+8.0$
14	-4.4	-4.1	-21.7	-6.8	-43.6	-5.2	-40.9	$+2.0$	-21.9	$+8.7$	-9.8	$+6.4$
15	-9.5	-3.8	-30.1	-6.6	-44.5	-3.5	-37.6	$+3.7$	-16.8	$+8.3$	-8.1	$+4.4$
16	-15.6	-3.6	-36.5	-5.8	-40.1	-2.1	-30.8	$+5.5$	-12.4	$+7.4$	-7.1	$+2.3$
17	-21.6	-3.6	-38.1	-4.9	-31.6	-0.8	-22.0	$+6.3$	-10.2	$+5.7$	-6.8	-0.2
18	-26.4	-3.7	-35.1	-4.3	-22.2	$+0.4$	-15.2	$+7.0$	-9.5	$+4.0$	-7.6	-2.2
19	-28.6	-3.4	-27.9	-3.5	-14.4	$+1.7$	-10.6	$+6.9$	-9.2	$+1.7$	-8.4	-4.1
20	-28.2	-3.2	-19.6	-3.2	-9.2	$+2.5$	-8.4	$+6.1$	-9.1	-0.5	-9.1	-5.9
21	-24.1	-2.8	-13.5	-2.4	-6.4	$+3.3$	-7.4	$+4.7$	-8.5	-2.1	-8.8	-6.6
22	-19.3	-2.5	-9.6	-1.2	-5.4	$+3.4$	-7.1	$+2.9$	-7.3	-3.7	-7.2	-7.3
23	-14.6	-1.7	-7.9	$+0.3$	-5.6	$+3.0$	-7.2	$+1.0$	-6.5	-4.7	-5.8	-7.2
24	-11.7	-0.6	-7.3	$+2.1$	-7.2	$+2.1$	-7.4	-0.5	-6.6	-5.0	-5.5	-7.1
25	-10.8	$+1.0$	-7.8	$+3.2$	-9.5	$+1.0$	-8.4	-2.0	-7.6	-5.1	-6.3	-6.5
26	-10.7	$+2.9$	-9.0	$+3.6$	-12.5	-0.4	-9.9	-3.2	-9.1	-4.9	-7.8	-6.2
27	-10.0	$+4.6$	-11.0	$+3.3$	-14.7	-1.7	-11.6	-3.9	-9.9	-4.6	-8.8	-5.6
28	-9.6	$+5.7$	-13.5	$+2.9$	-15.2	-2.7	-12.5	-4.1	-9.9	-4.3	-8.7	-4.9
29	-9.2	$+6.1$	-15.2	$+1.6$	-13.4	-3.3	-11.8	-4.0	-8.2	-3.9	-7.7	-4.3
30	-9.5	$+5.9$	-15.0	$+0.1$	-10.1	-3.5	-9.8	-3.9	-6.7	-3.8	-7.4	-4.0
31	-9.8	$+4.6$	-12.0	-0.9	...	...	-7.2	-4.1	...	...	-8.0	-3.6

HANSEN—BURCKHARDT.

1853. Day.	January. Long. Lat.		February. Long. Lat.		March. Long. Lat.		April. Long. Lat.		May. Long. Lat.		June. Long. Lat.	
1	−10.4	−3.0	−13.8	+3.2	−12.8	+6.1	−4.0	+9.3	+1.1	+3.0	+2.9	−5.4
2	−11.5	−1.9	−10.6	+5.4	−11.6	+8.0	−0.5	+8.1	+3.9	+0.8	+4.8	−6.1
3	−11.1	−0.1	−4.8	+7.4	−8.8	+9.4	+4.1	+6.1	+7.0	−1.2	+6.0	−6.3
4	−8.3	+1.9	+2.0	+8.6	−3.6	+9.7	+9.2	+4.0	+8.8	−3.0	+5.1	−6.1
5	−3.5	+3.4	+8.1	+8.9	+3.0	+9.6	+12.6	+1.9	+8.8	−4.0	+2.6	−5.8
6	+1.1	+5.7	+11.9	+8.8	+9.7	+7.9	+13.1	0.0	+6.5	−4.5	−1.0	−5.2
7	+4.0	+7.2	+12.0	+7.9	+14.2	+6.0	+10.4	−1.3	+2.1	−4.9	−5.3	−4.8
8	+4.6	+8.1	+9.5	+6.6	+15.3	+4.6	+6.1	−2.6	−2.4	−5.1	−8.8	−4.3
9	+3.3	+8.4	+6.0	+5.0	+13.3	+3.0	+1.6	−3.4	−6.0	−5.2	−11.7	−3.9
10	+0.7	+7.7	+3.0	+3.4	+9.4	+1.6	−2.0	−4.2	−8.2	−5.1	−13.8	−3.4
11	−2.0	+6.6	+0.9	+1.6	+5.3	+0.1	−3.9	−4.6	−8.7	−5.1	−14.0	−2.6
12	−3.4	+4.7	−0.4	+0.2	+2.4	−0.9	−4.6	−5.5	−9.0	−5.4	−13.5	−2.4
13	−3.7	+2.7	−2.2	−1.4	−0.1	−2.0	−4.9	−5.9	−8.7	−5.3	−12.9	−1.8
14	−3.1	+0.6	−4.6	−2.6	−1.9	−3.2	−4.6	−7.1	−8.8	−5.6	−13.2	−1.5
15	−4.0	−1.3	−6.5	−4.3	−3.5	−4.1	−5.2	−7.7	−9.3	−5.9	−13.4	−0.6
16	−5.6	−3.2	−7.7	−5.4	−4.8	−5.2	−5.6	−8.3	−10.0	−5.7	−12.8	+0.9
17	−7.8	−4.9	−7.2	−6.5	−5.1	−6.7	−5.9	−9.1	−10.8	−5.3	−11.9	+2.4
18	−9.3	−6.1	−5.4	−7.2	−4.8	−7.7	−5.8	−8.9	−11.1	−4.6	−11.0	+4.1
19	−9.0	−7.1	−3.4	−7.7	−3.6	−8.4	−5.7	−8.4	−11.5	−3.5	−10.7	+6.0
20	−7.7	−7.7	−2.4	−7.3	−2.5	−8.7	−6.2	−7.5	−12.5	−2.1	−11.0	+7.1
21	−5.6	−8.0	−2.8	−6.9	−1.6	−8.1	−7.5	−5.9	−14.6	−0.3	−11.9	+7.8
22	−4.4	−7.8	−4.4	−5.8	−1.7	−7.4	−11.0	−4.0	−17.0	+1.8	−11.8	+7.5
23	−4.9	−7.5	−6.5	−4.5	−3.1	−6.1	−14.8	−1.6	−17.5	+3.6	−11.1	+6.2
24	−6.8	−6.6	−8.7	−2.5	−5.8	−4.1	−17.0	+1.2	−16.0	+4.5	−9.3	+4.6
25	−8.8	−6.0	−10.4	−1.0	−9.6	−2.0	−16.7	+3.3	−12.9	+4.7	−7.1	+2.5
26	−9.7	−4.9	−11.7	+0.7	−12.7	+0.5	−13.1	+5.0	−9.3	+3.8	−5.5	+0.4
27	−9.8	−3.8	−12.6	+2.3	−13.9	+2.9	−8.8	+5.8	−6.5	+2.9	−4.3	−1.8
28	−10.3	−2.9	−13.1	+4.2	−12.8	+4.9	−5.7	+6.5	−4.3	+1.1	−3.8	−3.6
29	−11.0	−1.9	...	...	−10.4	+7.0	−3.8	+6.3	−2.7	−0.6	−2.4	−5.1
30	−12.6	−0.7	...	...	−7.9	+8.5	−1.8	+5.0	−0.9	−2.4	−1.0	−6.1
31	−14.1	+1.3	...	...	−6.0	+9.5	...	...	+1.0	−4.3	...	...

HANSEN—BURCKHARDT.

1853. Day.	July. Long.	Lat.	August. Long.	Lat.	September. Long.	Lat.	October. Long.	Lat.	November. Long.	Lat.	December. Long.	Lat.
1	+1″.1	−6″.4	+0″.3	−6″.5	−21″.1	−8″.4	−33.6	−7″.4	−36″.8	+0″.7	−23″.6	+5″.3
2	+3.0	−6.6	−2.5	−6.8	−28.8	−7.9	−40.0	−5.7	−38.9	+3.3	−24.7	+6.2
3	+4.1	−6.4	−8.1	−6.6	−34.4	−7.3	−43.7	−3.8	−36.6	+5.2	−23.2	+6.2
4	+3.2	−6.1	−15.2	−6.4	−36.5	−6.2	−43.3	−1.4	−31.2	+6.9	−20.1	+4.9
5	−1.0	−5.3	−21.5	−5.9	−35.5	−5.3	−38.1	+0.6	−25.2	+7.2	−17.4	+3.6
6	−6.4	−4.8	−24.7	−5.6	−31.3	−4.4	−30.1	+2.6	−21.0	+6.9	−15.3	+1.9
7	−12.1	−4.5	−25.0	−5.2	−25.1	−3.5	−21.3	+3.5	−18.2	+6.1	−13.8	+0.1
8	−16.2	−4.1	−23.5	−5.0	−18.4	−2.2	−14.6	+4.8	−16.4	+4.3	−12.3	−1.6
9	−18.6	−3.3	−21.3	−4.9	−13.0	−0.9	−11.7	+5.4	−13.8	+2.4	−10.5	−3.4
10	−18.5	−3.0	−18.9	−4.3	−10.1	+0.5	−11.4	+5.1	−11.1	+0.5	−8.4	−4.8
11	−17.5	−2.5	−16.5	−3.0	−10.2	+2.0	−12.7	+4.2	−8.5	−1.0	−6.2	−5.1
12	−16.9	−2.2	−14.4	−1.3	−12.5	+2.8	−13.6	+2.6	−7.0	−2.1	−4.3	−5.5
13	−16.2	−1.4	−12.6	+0.9	−15.9	+2.7	−13.6	+0.9	−7.2	−2.8	−3.8	−5.3
14	−15.3	+0.2	−12.3	+3.2	−19.0	+2.6	−13.6	−0.4	−8.6	−3.0	−4.6	−4.8
15	−13.6	+2.0	−13.5	+5.1	−21.0	+1.6	−14.7	−1.2	−9.7	−3.3	−6.3	−4.2
16	−11.1	+4.4	−15.7	+6.2	−21.9	+1.0	−15.7	−2.2	−9.4	−3.1	−7.6	−3.6
17	−9.4	+6.7	−18.3	+6.6	−21.8	+0.4	−15.5	−2.6	−7.6	−2.6	−7.8	−2.2
18	−9.0	+8.5	−20.2	+6.3	−20.2	0.0	−12.8	−2.6	−4.8	−2.0	−7.0	−1.8
19	−10.3	+9.5	−20.7	+5.6	−16.5	−0.7	−8.0	−2.8	−1.8	−1.5	−5.7	−1.4
20	−12.3	+9.7	−19.5	+4.7	−10.9	−1.0	−2.1	−2.6	−0.8	−1.5	−4.8	−1.4
21	−13.7	+8.8	−16.7	+4.0	−4.9	−1.3	+2.2	−3.1	−1.6	−1.8	−4.6	−1.7
22	−13.6	+7.5	−12.7	+3.0	0.0	−2.2	+3.8	−3.4	−4.8	−2.2	−6.1	−1.8
23	−12.3	+5.7	−8.4	+1.3	+2.2	−3.0	+1.9	−4.3°	−8.0	−2.6	−8.0	−1.5
24	−10.3	+3.7	−4.5	0.0	+1.7	−4.4	−2.4	−5.3	−11.0	−2.7	−9.3	−1.2
25	−8.1	+1.7	−2.4	−1.3	−0.9	−5.8	−7.7	−5.9	−12.2	−2.6	−8.2	−0.1
26	−6.3	0.0	−1.4	−2.5	−4.8	−7.1	−12.4	−6.6	−12.1	−2.2	−5.4	+0.7
27	−4.9	−1.6	−1.2	−3.9	−9.5	−8.0	−15.8	−6.5	−11.4	−1.4	−2.7	+2.0
28	−3.7	−3.2	−2.0	−5.4	−14.8	−8.8	−18.0	−6.1	−12.0	−0.3	−2.0	+3.5
29	−2.4	−4.4	−4.0	−6.6	−20.4	−8.8	−20.7	−5.4	−15.2	+1.6	−4.8	+4.7
30	−0.5	−5.5	−7.6	−7.5	−26.9	−8.4	−25.0	−3.7	−19.6	+3.6	−9.2	+5.3
31	+0.5	−6.3	−13.5	−8.3	...	...	−31.1	−1.9	...	...	−11.7	+5.6

Comparison of Burckhardt's and Hansen's

HANSEN—BURCKHARDT.

1854. Day.	January. Long. Lat.		February. Long. Lat.		March. Long. Lat.		April. Long. Lat.		May. Long. Lat.		June. Long. Lat.	
1	−11.6	+4.3	−4.3	+2.2	−3.7	+1.5	−7.2	−4.8	−6.4	−4.9	−8.8	−0.1
2	−9.7	+3.3	−4.8	+0.7	−6.2	+0.3	−6.7	−5.5	−6.3	−4.7	−9.0	+0.4
3	−7.4	+1.8	−6.8	−1.0	−7.4	−1.4	−6.4	−6.0	−6.3	−4.2	−9.7	+0.7
4	−6.8	+0.3	−8.4	−2.9	−7.6	−2.9	−6.7	−6.3	−6.9	−3.9	−11.0	+0.9
5	−7.6	−1.7	−9.9	−4.6	−7.9	−3.9	−6.7	−6.1	−7.1	−3.5	−11.9	+1.3
6	−9.2	−3.6	−9.7	−5.8	−8.3	−5.0	−5.9	−6.0	−6.8	−3.6	−12.6	+1.8
7	−10.2	−5.3	−7.9	−6.3	−8.2	−5.5	−4.3	−5.5	−6.6	−3.3	−12.8	+2.5
8	−9.5	−6.5	−4.9	−6.4	−6.9	−5.8	−2.3	−5.0	−6.8	−3.1	−13.4	+3.1
9	−7.4	−7.0	−1.5	−5.9	−4.3	−5.4	−1.0	−4.7	−7.7	−2.9	−14.7	+3.8
10	−4.2	−7.2	+0.5	−5.3	−1.3	−4.9	−0.9	−4.0	−9.5	−2.0	−16.7	+4.6
11	−1.8	−6.8	+0.5	−4.6	+0.9	−4.1	−3.0	−3.1	−12.9	−1.0	−18.7	+4.8
12	−1.1	−6.3	−1.6	−4.2	+1.3	−3.8	−6.6	−1.7	−16.3	+0.5	−19.0	+4.3
13	−2.3	−5.5	−4.2	−3.6	−0.3	−3.0	−10.5	+0.1	−18.9	+2.2	−16.8	+3.2
14	−4.8	−4.8	−6.8	−2.9	−3.2	−2.1	−14.3	+2.0	−19.9	+3.4	−13.2	+1.7
15	−7.1	−4.3	−8.4	−2.5	−6.7	−0.9	−16.5	+4.6	−18.5	+3.8	−9.7	+0.1
16	−8.1	−3.6	−9.5	−2.0	−10.0	+0.7	−17.3	+6.6	−16.0	+3.5	−6.7	−1.8
17	−7.8	−3.5	−11.5	−1.1	−13.1	+2.5	−16.7	+8.1	−12.9	+2.7	−4.2	−3.5
18	−6.9	−3.4	−13.6	+0.4	−15.2	+4.8	−15.6	+8.3	−9.7	+1.4	−2.1	−5.0
19	−6.7	−3.4	−14.1	+2.3	−16.5	+6.8	−14.1	+7.4	−7.1	−0.7	0.0	−6.5
20	−8.0	−2.9	−12.8	+3.7	−16.7	+8.2	−12.1	+5.6	−4.4	−2.6	+2.5	−7.3
21	−9.4	−2.1	−8.5	+5.0	−15.1	+8.6	−8.5	+3.0	−1.2	−4.5	+3.7	−7.9
22	−9.9	−0.5	−2.1	+5.6	−12.0	+8.3	−4.0	+0.7	+1.6	−5.9	+3.8	−7.6
23	−7.3	+1.1	+3.6	+5.7	−7.4	+6.6	+0.5	−1.8	+3.0	−6.6	+1.8	−6.9
24	−2.1	+2.7	+8.2	+5.3	−1.7	+4.7	+3.5	−3.6	+2.6	−7.3	−1.6	−5.8
25	+3.2	+4.1	+9.6	+5.1	+3.7	+2.8	+3.8	−5.1	0.0	−7.1	−5.9	−4.7
26	+6.0	+4.9	+7.9	+4.3	+7.4	+1.1	+1.3	−5.5	−3.3	−6.6	−10.0	−3.4
27	+4.8	+5.6	+4.3	+3.4	+7.8	−0.4	−2.7	−5.9	−6.5	−5.9	−12.6	−2.2
28	+1.6	+5.8	0.0	+2.5	+4.8	−1.4	−5.5	−6.1	−8.5	−4.5	−13.6	−0.8
29	−2.0	+5.2	...	...	+0.2	−2.5	−6.9	−6.0	−9.5	−3.0	−13.7	−0.1
30	−3.6	+4.5	...	...	−4.1	−3.5	−6.9	−5.5	−9.4	−1.8	−13.2	+0.5
31	−4.0	+3.4	...	...	−6.8	−4.3	...	...	−9.2	−0.8	...	...

HANSEN—BURCKHARDT.

1854.	July.		August.		September.		October.		November.		December.	
Day.	Long.	Lat.	Long.	Lat.	Long.	Lat.	Long.	Lat.	Long.	Lat.	Long.	Lat.
1	−13″5	+1″1	−20″0	+0″2	−19″2	+1″2	−16″7	+0″1	−14″3	−2″6	−7″2	−5″0
2	−14·6	+1·5	−19·6	+2·1	−19·8	+1·6	−18·2	−1·0	−13·1	−3·8	−5·6	−5·1
3	−15·7	+2·5	−18·7	+3·9	−20·4	+1·4	−19·7	−2·1	−12·1	−4·0	−5·3	−4·6
4	−16·6	+3·6	−17·4	+5·5	−22·1	+1·2	−20·7	−3·2	−11·1	−4·5	−6·4	−3·4
5	−16·1	+5·2	−16·6	+6·7	−23·6	+0·8	−21·1	−4·1	−10·0	−4·1	−6·7	−2·1
6	−14·6	+6·7	−17·4	+6·9	−25·5	+0·6	−20·3	−4·3	−8·2	−3·4	−5·9	−0·6
7	−13·3	+7·6	−19·3	+7·1	−25·3	+0·2	−17·8	−4·4	−5·2	−2·4	−3·9	+0·7
8	−13·5	+8·6	−21·1	+6·8	−23·3	−0·1	−13·6	−4·3	−1·7	−1·4	−1·5	+1·6
9	−15·2	+8·6	−21·4	+6·3	−19·1	−0·6	−8·6	−3·7	+1·0	−0·5	+0·2	+1·8
10	−17·3	+8·2	−19·9	+5·3	−13·4	−1·1	−3·8	−3·5	+1·8	0·0	0·0	+1·8
11	−17·7	+7·4	−16·9	+4·3	−8·4	−1·6	−0·1	−2·7	+0·6	+0·3	−2·1	+1·6
12	−15·6	+6·0	−12·8	+2·8	−4·4	−2·0	+1·1	−2·5	−1·7	+0·3	−5·4	+1·4
13	−12·2	+4·4	−8·8	+1·2	−2·2	−2·4	−0·6	−2·5	−4·2	0·0	−7·9	+1·4
14	−9·1	+2·4	−6·4	−0·3	−2·2	−2·9	−3·4	−2·2	−6·6	−0·4	−9·3	+1·3
15	−7·1	+0·5	−4·3	−1·7	−4·1	−2·9	−6·5	−2·0	−8·4	−0·9	−9·2	+1·3
16	−5·4	−1·5	−3·1	−2·7	−7·0	−2·7	−9·3	−2·1	−10·5	−1·1	−8·5	+1·1
17	−3·9	−3·5	−3·0	−3·5	−9·7	−2·6	−12·3	−2·6	−13·2	−1·3	−9·3	+1·4
18	−2·3	−4·9	−3·3	−3·7	−12·9	−2·7	−16·3	−2·8	−16·7	−1·1	−12·9	+1·3
19	0·0	−5·8	−4·1	−3·7	−16·9	−2·7	−21·4	−3·0	−21·4	−0·5	−18·7	+1·1
20	+1·6	−6·2	−6·1	−3·4	−22·1	−3·1	−26·9	−2·8	−26·3	+0·3	−23·5	+0·9
21	+2·0	−6·0	−9·2	−3·3	−27·7	−3·4	−31·3	−2·2	−29·8	+0·9	−25·6	+0·4
22	+0·9	−5·5	−14·0	−3·3	−31·7	−3·6	−33·4	−1·7	−30·1	+1·4	−22·8	−0·6
23	−2·3	−4·7	−19·3	−3·2	−32·3	−3·3	−31·8	−0·5	−27·8	+1·5	−17·9	−0·9
24	−6·6	−3·8	−23·7	−3·5	−29·6	−3·1	−27·7	+0·5	−23·4	+1·2	−13·7	−1·5
25	−11·7	−3·3	−26·2	−3·7	−24·8	−2·5	−23·3	+1·5	−19·3	+0·9	−11·9	−2·7
26	−15·9	−2·7	−26·0	−4·0	−19·3	−1·5	−19·0	+2·2	−16·4	+0·6	−11·9	−4·0
27	−18·4	−2·7	−23·9	−3·8	−15·5	−0·2	−15·7	+2·4	−15·5	−0·7	−11·6	−5·3
28	−20·0	−2·4	−21·2	−3·7	−14·0	+0·6	−14·3	+2·5	−14·8	−2·2	−9·6	−6·7
29	−20·2	−2·4	−19·2	−2·6	−14·2	+0·9	−14·2	+1·8	−13·2	−3·5	−6·3	−7·0
30	−19·7	−2·0	−18·6	−1·4	−15·4	+0·9	−14·5	+0·2	−10·2	−4·6	−3·1	−6·9
31	−19·6	−1·4	−18·7	+0·1	...	...	−15·0	−1·0	...	...	−1·4	−6·1

HANSEN—BURCKHARDT.

1855. Day.	January. Long. Lat.		February. Long. Lat.		March. Long. Lat.		April. Long. Lat.		May. Long. Lat.		June. Long. Lat.	
1	−1.3	−5.1	+1.0	−1.3	+3.3	+0.9	−1.5	+2.5	−6.2	+1.9	−13.1	+1.9
2	−2.8	−4.1	−1.2	−0.9	+3.8	+1.0	−4.3	+2.4	−7.8	+1.9	−15.6	+0.9
3	−4.7	−2.4	−3.2	−1.0	+1.6	+0.8	−7.7	+3.0	−9.7	+2.4	−16.4	0.0
4	−5.3	−1.0	−5.0	−0.8	−2.6	+1.0	−9.8	+3.8	−11.7	+2.7	−15.6	−1.3
5	−5.0	−0.1	−6.5	−1.1	−6.5	+0.9	−11.4	+4.8	−14.4	+2.7	−13.5	−2.4
6	−3.7	+0.2	−7.2	−1.2	−9.3	+1.6	−13.0	+5.8	−16.5	+2.7	−11.0	−3.9
7	−2.7	+0.4	−7.9	−0.9	−10.6	+2.2	−14.4	+6.4	−16.8	+1.9	−8.4	−5.7
8	−3.0	+0.4	−8.4	−0.3	−10.9	+2.7	−15.6	+6.3	−15.0	+0.4	−5.7	−7.4
9	−5.0	+0.3	−9.1	+0.8	−10.1	+3.8	−14.6	+5.2	−11.8	−1.7	−2.2	−8.8
10	−7.8	+0.6	−8.8	+1.9	−10.0	+4.2	−10.7	+3.3	−7.7	−4.2	+1.3	−9.9
11	−10.4	+1.1	−7.0	+2.5	−8.7	+4.3	−4.7	+1.0	−3.5	−5.6	+4.1	−10.1
12	−11.5	+1.7	−4.4	+2.8	−5.9	+3.9	+0.9	−1.3	+0.8	−7.5	+4.4	−9.8
13	−10.5	+2.4	−1.4	+2.6	−1.2	+2.7	+4.8	−3.3	+4.1	−8.7	+1.9	−8.8
14	−8.4	+2.8	−0.5	+1.7	+3.5	+1.6	+5.3	−5.0	+5.5	−9.1	−2.6	−7.4
15	−7.0	+2.6	−2.9	+0.9	+6.1	+0.2	+3.2	−6.5	+4.7	−9.4	−6.7	−5.6
16	−8.2	+2.2	−7.7	+0.2	+4.3	−1.1	0.0	−7.5	+1.7	−8.4	−9.2	−3.4
17	−11.7	+1.6	−11.9	−0.5	−1.0	−2.6	−3.3	−7.8	−1.9	−7.2	−9.5	−1.7
18	−15.3	+0.8	−12.8	−1.2	−7.2	−3.5	−5.9	−7.5	−4.6	−5.2	−8.5	+0.2
19	−16.5	+0.2	−11.4	−1.6	−11.3	−4.5	−7.1	−6.7	−6.4	−3.3	−7.7	+1.2
20	−14.4	−0.4	−8.7	−2.0	−12.2	−5.1	−7.7	−5.6	−6.6	−1.5	−7.6	+2.3
21	−10.4	−0.9	−6.4	−2.7	−10.8	−5.2	−8.2	−4.2	−7.1	+0.1	−8.6	+3.1
22	−7.0	−1.8	−5.8	−3.3	−9.0	−5.3	−9.1	−2.9	−8.0	+1.6	−9.8	+4.3
23	−5.9	−2.8	−6.7	−3.6	−8.6	−4.8	−10.5	−1.2	−9.4	+2.7	−10.1	+5.6
24	−6.0	−4.2	−8.0	−3.4	−9.3	−3.9	−11.7	+0.3	−10.4	+3.5	−10.1	+6.7
25	−6.6	−5.6	−8.5	−2.8	−10.9	−2.9	−12.3	+1.2	−10.4	+4.2	−9.4	+7.5
26	−6.3	−6.2	−6.8	−1.9	−12.1	−1.5	−11.1	+2.2	−9.7	+4.2	−8.8	+8.0
27	−5.3	−6.4	−3.5	−0.6	−11.5	0.0	−9.1	+2.3	−8.1	+4.3	−9.3	+7.8
28	−2.8	−5.5	+0.4	+0.3	−8.9	+1.1	−6.6	+2.3	−7.3	+4.1	−11.6	+7.3
29	−0.1	−4.5	...	...	−5.0	+2.0	−5.4	+1.9	−7.3	+3.9	−14.8	+6.1
30	+1.6	−3.2	...	...	−1.6	+2.3	−5.4	+1.8	−8.1	+3.3	−17.7	+4.5
31	+2.1	−2.3	...	...	−0.3	+2.2	...	...	−10.2	+2.5	...	...

HANSEN—BURCKHARDT.

1855. Day.	July. Long.	Lat.	August. Long.	Lat.	September. Long.	Lat.	October. Long.	Lat.	November. Long.	Lat.	December. Long.	Lat.
1	−18.3	+3.1	−11.4	+1.4	−4.9	−3.6	−5.9	−4.1	−5.1	0.0	−4.4	+1.9
2	−16.4	+1.4	−7.7	0.0	−3.7	−3.7	−5.8	−3.0	−5.8	+0.9	−5.4	+2.6
3	−13.0	−0.1	−5.0	−2.2	−3.6	−3.7	−6.2	−1.9	−6.6	+1.3	−5.6	+3.0
4	−10.0	−1.7	−3.2	−3.6	−4.6	−2.8	−6.8	−0.5	−7.3	+1.3	−5.2	+3.0
5	−7.3	−3.6	−2.1	−4.6	−5.3	−1.9	−7.5	+0.4	−7.9	+1.6	−5.4	+2.9
6	−4.9	−5.5	−1.7	−4.9	−6.0	−1.0	−8.2	+0.8	−9.0	+1.1	−7.4	+2.6
7	−2.9	−7.1	−1.6	−4.6	−6.7	−0.1	−9.4	+0.8	−12.0	+1.0	−11.4	+2.6
8	−0.5	−8.2	−2.5	−4.0	−8.7	+0.4	−11.6	+0.8	−15.6	+0.4	−16.7	+2.2
9	+1.6	−8.5	−4.7	−2.9	−11.5	+0.5	−15.2	0.0	−19.7	+0.4	−21.5	+1.5
10	+1.8	−8.2	−7.8	−2.2	−15.5	+0.6	−19.2	−0.2	−22.4	−0.1	−24.2	+1.1
11	−0.5	−7.4	−11.8	−1.3	−20.0	0.0	−22.6	−0.2	−22.5	−0.4	−23.6	+0.5
12	−4.7	−6.2	−16.2	−1.0	−23.0	−0.3	−23.9	−0.7	−19.7	−0.6	−20.5	+0.1
13	−9.6	−4.9	−19.2	−0.5	−24.0	−0.8	−22.3	−1.0	−16.0	−0.5	−16.4	−0.3
14	−13.5	−3.6	−20.7	−0.9	−22.8	−1.1	−18.8	−1.0	−12.7	−0.1	−13.0	−0.5
15	−15.6	−2.1	−20.8	−0.8	−20.3	−1.3	−13.9	−0.9	−10.6	+0.4	−11.8	−1.1
16	−15.6	−1.2	−19.7	−1.3	−17.9	−1.1	−12.9	−0.6	−9.8	+0.5	−11.9	−2.7
17	−14.3	−0.6	−18.2	−1.2	−16.8	−0.8	−12.2	−0.2	−10.3	−0.1	−12.4	−4.0
18	−13.0	+0.1	−17.3	−0.6	−17.4	−0.2	−12.4	+0.2	−10.4	−1.3	−11.9	−5.8
19	−12.3	+0.7	−17.1	+0.5	−18.8	+0.2	−12.3	−0.3	−10.0	−2.8	−9.7	−6.7
20	−12.3	+1.7	−18.1	+2.1	−19.5	0.0	−11.4	−1.5	−8.9	−4.6	−6.9	−7.2
21	−12.9	+2.9	−19.7	+3.4	−18.5	−0.8	−10.3	−2.5	−7.4	−5.7	−5.1	−6.8
22	−13.5	+4.8	−21.0	+4.2	−16.7	−2.0	−9.8	−4.0	−6.5	−6.0	−4.4	−5.8
23	−14.2	+6.5	−21.2	+4.3	−15.9	−2.9	−10.2	−5.3	−6.0	−6.1	−5.0	−4.4
24	−14.5	+8.0	−20.6	+3.5	−16.4	−3.8	−10.7	−6.6	−6.9	−5.2	−6.0	−3.3
25	−14.6	+8.5	−20.5	+2.9	−17.8	−5.0	−11.3	−7.1	−7.7	−4.0	−5.7	−1.6
26	−15.8	+8.9	−21.0	+2.0	−18.1	−5.8	−11.0	−7.0	−7.6	−2.6	−4.3	−0.9
27	−17.4	+8.2	−21.1	+0.9	−16.1	−6.3	−10.4	−6.1	−6.3	−1.2	−2.8	+0.2
28	−19.3	+7.1	−20.2	0.0	−12.5	−6.1	−9.0	−5.2	−4.2	0.0	−2.1	+0.5
29	−20.0	+5.8	−16.9	−0.9	−9.3	−5.9	−7.3	−3.7	−3.3	+1.0	−3.0	+1.0
30	−18.9	+4.4	−12.3	−1.6	−6.9	−4.9	−6.0	−2.4	−3.6	+1.8	−4.4	+1.5
31	−15.8	+3.1	−7.8	−2.8	...	...	−5.3	−1.0	...	...	−5.6	+2.5

HANSEN—BURCKHARDT.

1856.	January.		February.		March.		April.		May.		June.	
Day.	Long.	Lat.	Long.	Lat.	Long.	Lat.	Long.	Lat.	Long.	Lat.	Long.	Lat.
1	−6″0	+3″5	−6·5	+4″2	−2″0	+3″4	+6″2	+0″9	+10″3	−5″7	+10″3	−11″5
2	−5·6	+4·2	−6·6	+4·0	+0·1	+3·2	+6·4	−0·5	+11·9	−7·7	+6·9	−11·2
3	−5·6	+4·3	−7·7	+3·4	+0·8	+2·4	+2·8	−2·6	+9·4	−9·2	+1·6	−10·5
4	−6·7	+4·3	−10·9	+2·2	−1·9	+1·1	−3·4	−5·1	+4·7	−10·0	−3·5	−9·0
5	−9·8	+4·0	−16·3	+0·9	−8·1	−0·3	−9·4	−7·0	0·0	−10·1	−6·7	−7·3
6	−14·9	+3·0	−22·4	−0·8	−15·8	−2·6	−12·9	−8·2	−3·7	−9·2	−8·2	−5·2
7	−20·3	+1·7	−26·2	−2·4	−22·0	−4·6	−13·0	−8·4	−4·9	−7·5	−9·1	−3·0
8	−24·3	+0·5	−25·2	−3·9	−23·3	−6·3	−10·8	−7·4	−5·3	−5·4	−9·7	−0·9
9	−25·4	−0·4	−20·3	−4·8	−19·8	−6·9	−8·4	−5·6	−5·9	−3·0	−10·1	+1·0
10	−23·1	−1·6	−14·6	−5·5	−14·8	−7·0	−7·5	−3·8	−7·7	−1·0	−11·1	+2·9
11	−18·5	−2·6	−10·5	−6·1	−10·5	−6·3	−8·2	−1·9	−10·6	+0·9	−11·3	+4·3
12	−14·0	−3·2	−9·1	−6·5	−9·2	−5·2	−10·3	+0·3	−13·8	+3·0	−10·2	+5·9
13	−11·2	−4·6	−9·3	−6·2	−9·1	−3·7	−12·4	+2·2	−15·2	+4·4	−7·6	+6·6
14	−10·6	−6·0	−9·2	−5·3	−9·7	−1·7	−12·9	+3·7	−14·4	+5·1	−5·4	+6·9
15	−11·0	−7·2	−7·3	−3·8	−9·0	+0·3	−11·7	+4·9	−11·6	+5·3	−4·2	+6·5
16	−10·5	−7·8	−4·1	−2·0	−7·1	+2·0	−9·0	+5·2	−7·3	+5·3	−4·7	+6·1
17	−8·3	−7·5	−1·1	−0·8	−4·4	+3·4	−6·2	+5·3	−4·0	+4·9	−6·4	+5·0
18	−5·1	−6·5	+0·5	+0·4	−2·0	+4·3	−4·2	+4·7	−3·0	+4·1	−8·7	+3·5
19	−2·5	−5·1	+1·2	+1·2	−1·1	+4·2	−3·9	+4·2	−3·6	+3·1	−10·2	+2·6
20	−1·4	−3·8	0·0	+1·2	−1·7	+4·1	−5·4	+3·8	−5·9	+2·3	−11·7	+1·3
21	−1·7	−2·9	−2·8	+1·4	−3·5	+3·8	−7·8	+3·5	−8·0	+1·2	−13·5	+0·1
22	−2·5	−2·0	−4·5	+1·1	−5·9	+3·6	−10·1	+3·1	−10·2	+0·4	−15·0	−1·5
23	−3·3	−1·6	−4·9	+1·1	−8·1	+3·7	−11·5	+3·3	−12·6	−0·3	−15·4	−3·1
24	−3·4	−0·9	−5·2	+1·2	−9·0	+3·6	−12·2	+3·1	−14·2	−1·0	−14·0	−5·2
25	−2·7	−0·5	−4·9	+1·8	−9·3	+4·2	−12·1	+3·0	−15·6	−2·3	−10·3	−7·0
26	−2·3	−0·1	−4·7	+2·6	−8·9	+4·2	−11·7	+2·3	−15·1	−3·6	−5·7	−8·9
27	−2·7	+0·3	−4·6	+3·0	−8·0	+4·3	−9·9	+1·2	−11·6	−5·2	−1·4	−9·8
28	−3·8	+1·2	−4·3	+3·4	−6·5	+4·3	−6·2	+0·2	−5·1	−6·8	+1·4	−10·3
29	−5·1	+2·3	−3·4	+3·3	−4·1	+3·9	−0·7	−1·6	+2·3	−8·4	+1·8	−10·2
30	−6·2	+3·1	...	...	−0·5	+3·3	+5·3	−3·8	+8·5	−9·8	−0·1	−9·9
31	−6·6	+3·9	...	...	+3·7	+2·4	...	...	+11·4	−11·0	...	...

HANSEN—BURCKHARDT.

1856. Day.	July. Long. Lat.		August. Long. Lat.		September. Long. Lat.		October. Long. Lat.		November. Long. Lat.		December. Long. Lat.	
1	$-3''.9$	$-8''.8$	$-22''.2$	$-1''.6$	$-22''.2$	$+0''.4$	$-21''.2$	$-0''.9$	$-20''.6$	$-2''.1$	$-16''.0$	$+0''.9$
2	-8.5	-7.4	-22.8	-1.3	-18.8	0.0	-19.2	-1.5	-16.7	-1.7	-12.3	$+1.6$
3	-12.6	-6.2	-20.7	-1.3	-14.6	-0.5	-16.7	-2.1	-13.1	-1.2	-11.2	$+1.8$
4	-15.2	-4.6	-16.1	-1.2	-11.4	-1.0	-14.8	-2.2	-11.0	-0.5	-11.4	$+1.6$
5	-15.4	-3.4	-11.8	-0.9	-10.1	-0.9	-13.5	-1.9	-11.0	-0.3	-12.9	$+0.1$
6	-13.7	-1.3	-8.0	-0.5	-11.3	-0.4	-13.1	-1.6	-11.5	-0.7	-13.7	-1.9
7	-11.3	$+0.2$	-6.4	$+0.4$	-13.1	$+0.1$	-12.8	-1.3	-11.5	-1.5	-12.3	-3.5
8	-8.7	$+0.6$	-6.4	$+1.6$	-14.5	$+0.8$	-12.6	-1.1	-9.2	-2.6	-10.8	-4.8
9	-7.4	$+1.8$	-8.2	$+2.7$	-15.5	$+1.1$	-11.2	-1.3	-6.8	-3.9	-10.0	-5.6
10	-6.6	$+3.6$	-10.2	$+4.0$	-14.5	$+1.3$	-9.4	-1.9	-5.6	-5.0	-9.9	-6.0
11	-6.0	$+4.9$	-12.5	$+4.8$	-13.9	$+1.0$	-7.7	-2.3	-6.8	-6.1	-10.4	-5.9
12	-6.0	$+6.3$	-14.5	$+5.3$	-13.8	$+0.5$	-7.8	-4.0	-9.3	-6.4	-10.0	-5.0
13	-6.8	$+7.3$	-15.9	$+5.3$	-14.7	-0.6	-8.9	-5.6	-11.0	-5.8	-9.9	-4.3
14	-8.7	$+7.6$	-17.2	$+4.9$	-15.2	-1.8	-10.6	-6.5	-11.7	-5.0	-9.4	-3.5
15	-11.3	$+7.6$	-18.7	$+4.1$	-15.1	-3.6	-12.3	-6.6	-11.3	-3.7	-9.0	-2.3
16	-13.6	$+6.8$	-19.6	$+3.0$	-13.1	-4.7	-13.2	-6.4	-10.6	-2.2	-8.5	-1.0
17	-15.5	$+6.0$	-17.7	$+1.7$	-11.3	-5.7	-13.8	-5.4	-10.5	-0.7	-8.3	$+0.2$
18	-16.5	$+4.8$	-14.1	-0.6	-10.6	-6.4	-13.7	-4.1	-10.3	$+0.8$	-8.0	$+1.7$
19	-16.9	$+3.1$	-10.7	-2.7	-11.3	-6.0	-13.4	-2.6	-11.1	$+1.9$	-7.7	$+2.9$
20	-16.0	$+1.6$	-7.4	-4.1	-11.9	-5.1	-12.5	-1.2	-10.1	$+2.9$	-7.7	$+3.7$
21	-14.0	-0.7	-6.3	-5.1	-11.9	-3.7	-11.4	$+0.2$	-9.2	$+3.7$	-6.8	$+4.6$
22	-11.1	-2.6	-6.9	-5.6	-10.5	-2.1	-9.9	$+1.1$	-7.7	$+3.9$	-5.5	$+4.3$
23	-8.3	-4.7	-8.7	-5.1	-8.8	-0.8	-8.2	$+1.9$	-6.9	$+3.8$	-5.5	$+3.8$
24	-6.8	-6.4	-9.1	-4.0	-7.6	$+0.3$	-7.3	$+2.0$	-6.4	$+3.4$	-7.6	$+3.$
25	-6.1	-7.0	-9.1	-2.7	-7.7	$+0.3$	-7.3	$+2.0$	-8.5	$+2.9$	-11.6	$+3.5$
26	-6.3	-7.1	-9.3	-1.4	-10.1	$+1.4$	-8.7	$+1.6$	-13.6	$+2.2$	-16.7	$+3.2$
27	-7.0	-6.3	-11.0	-0.5	-13.4	$+1.2$	-12.1	$+1.1$	-18.9	$+1.7$	-21.1	$+2.8$
28	-8.3	-5.5	-14.5	$+0.8$	-17.3	$+1.2$	-16.6	$+0.6$	-22.8	$+1.0$	-22.7	$+2.6$
29	-10.5	-4.2	-19.0	$+1.1$	-20.0	$+0.6$	-20.5	-0.3	-23.0	$+0.6$	-21.4	$+2.3$
30	-14.0	-2.9	-22.4	$+1.6$	-21.5	-0.3	-23.3	-1.1	-20.6	$+0.5$	-18.5	$+2.3$
31	-18.8	-2.1	-23.8	$+0.7$	...	...	-22.7	-1.8	...	...	-15.2	$+1.6$

HANSEN—BURCKHARDT.

1857. Day.	January. Long.	Lat.	February. Long.	Lat.	March. Long.	Lat.	April. Long.	Lat.	May. Long.	Lat.	June. Long.	Lat.
1	-12.7	$+1.4$	-13.6	-5.0	-15.8	-5.8	-10.5	-1.9	-9.1	$+0.9$	-12.7	$+3.8$
2	-12.1	-0.3	-15.2	-5.3	-14.5	-5.3	-11.6	-0.1	-11.6	$+2.4$	-11.9	$+4.3$
3	-12.6	-2.0	-17.0	-4.4	-15.4	-3.9	-12.2	$+1.6$	-12.5	$+3.6$	-9.6	$+4.0$
4	-13.8	-3.4	-16.5	-3.3	-15.7	-2.2	-12.0	$+3.1$	-11.7	$+4.3$	-6.9	$+3.1$
5	-14.6	-4.5	-13.9	-2.0	-14.9	-0.5	-10.4	$+3.8$	-9.4	$+4.1$	-4.5	$+2.2$
6	-14.7	-4.8	-11.0	-1.3	-12.4	$+1.1$	-8.8	$+4.0$	-7.3	$+3.5$	-4.2	$+0.9$
7	-13.6	-4.5	-8.9	-0.9	-9.6	$+1.9$	-7.9	$+3.6$	-6.1	$+2.5$	-4.8	0.0
8	-12.0	-4.5	-8.6	-0.9	-8.2	$+2.5$	-7.6	$+2.9$	-6.4	$+1.5$	-6.4	-0.6
9	-10.5	-4.1	-9.7	-0.7	-8.1	$+2.5$	-8.4	$+2.2$	-7.5	$+0.2$	-8.7	-1.5
10	-9.9	-3.6	-10.2	-0.5	-8.4	$+2.4$	-9.2	$+1.3$	-8.9	-0.8	-11.1	-1.8
11	-10.1	-3.2	-9.4	-0.1	-8.9	$+2.0$	-9.5	$+0.7$	-10.3	-1.7	-13.0	-2.6
12	-10.7	-2.7	-7.5	0.0	-8.4	$+1.8$	-9.8	-0.2	-11.3	-2.1	-14.8	-3.4
13	-10.4	-2.1	-5.5	$+0.3$	-7.3	$+1.4$	-9.7	-0.6	-11.6	-2.7	-15.9	-4.6
14	-9.1	-1.3	-5.1	$+0.7$	-6.3	$+1.2$	-9.4	-0.6	-12.2	-2.9	-15.3	-6.0
15	-7.8	-0.3	-5.3	$+1.2$	-5.8	$+1.0$	-8.8	-0.3	-12.1	-2.8	-12.3	-7.2
16	-6.7	$+0.6$	-5.7	$+1.7$	-5.9	$+1.2$	-7.8	0.0	-11.4	-3.5	-6.8	-8.4
17	-6.4	$+1.3$	-5.4	$+2.0$	-6.1	$+1.5$	-5.9	0.0	-8.6	-4.1	-0.2	-8.8
18	-6.1	$+2.1$	-4.2	$+2.4$	-5.6	$+2.1$	-3.2	$+0.4$	-3.1	-5.1	$+4.7$	-8.9
19	-5.9	$+2.6$	-2.9	$+2.6$	-3.5	$+2.6$	$+1.0$	$+0.5$	$+3.6$	-5.9	$+5.5$	-8.5
20	-5.2	$+2.8$	-2.3	$+2.9$	-0.6	$+2.7$	$+4.6$	0.0	$+9.2$	-6.9	$+1.8$	-8.3
21	-4.7	$+3.0$	-4.3	$+2.9$	$+1.6$	$+3.0$	$+6.3$	-0.7	$+10.6$	-7.9	-4.9	-7.6
22	-5.7	$+3.1$	-9.3	$+2.7$	$+2.2$	$+3.1$	$+4.7$	-2.3	$+6.5$	-8.5	-11.1	-7.2
23	-9.3	$+3.1$	-16.2	$+1.5$	-0.2	$+2.4$	-0.5	-4.0	-0.2	-8.4	-15.5	-6.3
24	-14.4	$+2.8$	-23.2	$+0.1$	-6.0	$+1.2$	-7.2	-4.7	-6.3	-8.2	-17.3	-5.3
25	-20.2	$+2.2$	-27.9	-2.0	-13.3	-1.0	-12.1	-5.2	-9.3	-7.2	-16.6	-4.0
26	-24.4	$+1.5$	-28.3	-4.0	-19.7	-3.3	-13.0	-5.2	-9.4	-6.2	-14.4	-2.7
27	-26.0	$+0.4$	-25.0	-5.0	-22.6	-4.5	-10.4	-4.5	-8.2	-4.7	-12.2	-1.4
28	-24.5	-0.5	-19.8	-5.6	-21.3	-4.9	-6.9	-3.7	-7.8	-3.1	-10.9	0.0
29	-20.8	-1.8	...	...	-16.9	-5.1	-5.5	-2.4	-8.5	-1.4	-10.0	$+1.1$
30	-16.5	-3.1	...	...	-12.7	-4.4	-6.5	-1.0	-10.4	$+0.8$	-10.4	$+1.8$
31	-13.8	-4.4	...	...	-10.6	-3.2	...	...	-12.1	$+2.6$	...	...

HANSEN—BURCKHARDT.

1857. Day.	July. Long.	Lat.	August. Long.	Lat.	September. Long.	Lat.	October. Long.	Lat.	November. Long.	Lat.	December. Long.	Lat.
1	−10.3	+1.9	−8.7	−1.0	−10.9	−1.3	−6.5	−2.8	−9.5	−4.0	−13.4	−2.3
2	−9.5	+2.0	−9.6	−0.6	−12.7	−1.0	−7.5	−3.0	−12.2	−3.2	−11.9	−1.5
3	−7.5	+2.4	−10.9	+0.1	−13.3	−0.7	−10.0	−3.0	−13.7	−2.3	−10.1	−0.9
4	−6.1	+1.7	−13.0	+0.5	−12.9	−0.9	−12.5	−3.1	−13.5	−1.4	−8.4	+0.4
5	−6.0	+1.0	−14.3	+0.8	−12.1	−1.6	−14.2	−3.3	−13.1	−0.1	−7.6	+1.5
6	−7.1	+1.0	−14.1	+0.6	−11.3	−2.4	−15.4	−3.1	−13.6	+1.5	−7.7	+2.8
7	−8.8	+0.6	−12.3	+0.1	−11.2	−3.3	−15.6	−2.5	−14.3	+3.1	−8.5	+4.9
8	−10.5	+0.5	−10.8	−0.8	−11.8	−3.8	−16.1	−1.9	−14.7	+4.7	−8.4	+5.3
9	−11.9	+0.1	−10.4	−2.2	−12.9	−3.8	−17.1	−0.7	−13.6	+5.7	−7.7	+5.8
10	−12.9	−0.8	−10.9	−3.5	−14.5	−3.1	−17.3	+0.9	−10.7	+6.2	−7.0	+5.5
11	−13.8	−2.1	−12.4	−4.0	−15.5	−1.6	−15.9	+2.3	−8.0	+5.9	−6.0	+4.6
12	−14.9	−3.6	−13.3	−3.9	−15.6	+0.2	−13.6	+3.3	−6.5	+5.4	−5.8	+3.4
13	−14.9	−5.1	−13.4	−2.7	−15.0	+1.8	−11.2	+3.9	−7.2	+4.3	−6.8	+2.0
14	−13.7	−6.1	−13.2	−1.3	−14.9	+3.4	−10.0	+4.2	−10.5	+3.1	−9.3	+0.9
15	−10.8	−6.0	−13.1	+0.6	−15.6	+4.4	−11.3	+3.9	−15.8	+1.3	−13.2	+0.5
16	−7.0	−5.3	−14.3	+2.3	−17.5	+4.5	−15.1	+3.1	−21.2	−0.4	−17.6	+0.1
17	−4.9	−4.5	−16.8	+3.7	−20.3	+5.1	−20.1	+2.1	−24.9	−1.6	−21.2	−0.1
18	−5.8	−3.1	−20.2	+4.4	−23.2	+4.3	−23.9	+0.6	−25.9	−2.7	−22.6	+0.2
19	−9.2	−2.1	−23.6	+4.7	−23.9	+3.0	−25.3	−1.5	−24.2	−3.0	−21.5	+1.2
20	−14.6	−1.2	−25.5	+4.6	−21.9	+1.3	−23.7	−3.0	−21.0	−3.1	−18.8	+1.5
21	−20.1	−0.7	−24.8	+3.8	−18.1	−0.6	−20.0	−4.4	−17.7	−2.5	−15.8	+1.9
22	−23.8	−0.4	−21.4	+2.5	−13.5	−2.0	−15.6	−4.9	−15.5	−2.1	−13.8	+1.5
23	−24.3	−0.3	−16.1	+1.2	−9.4	−3.4	−12.0	−5.1	−15.1	−2.0	−14.4	+0.3
24	−21.6	−0.3	−10.7	−0.5	−6.9	−3.6	−10.4	−4.7	−15.7	−2.7	−17.0	−0.7
25	−16.8	−0.3	−6.6	−1.6	−6.1	−4.2	−9.8	−4.4	−17.0	−3.5	−20.0	−1.9
26	−11.0	−0.7	−4.9	−2.6	−5.8	−3.9	−10.2	−4.2	−17.3	−4.3	−21.8	−2.3
27	−8.5	−0.9	−4.6	−2.7	−6.2	−3.6	−10.5	−4.4	−16.8	−4.7	−21.5	−2.3
28	−6.7	−0.8	−5.5	−2.8	−6.5	−3.4	−9.3	−4.5	−15.5	−4.7	−20.1	−1.7
29	−6.9	−1.0	−6.4	−2.8	−6.6	−3.1	−7.2	−4.9	−14.4	−4.2	−18.3	−1.2
30	−7.5	−1.4	−7.7	−2.1	−6.3	−2.9	−5.8	−4.6	−13.7	−3.1	−17.3	−0.7
31	−7.9	−1.3	−9.2	−1.6	...	...	−6.9	−4.2	...	...	−16.7	−1.0

HANSEN—BURCKHARDT.

1858.	January.		February.		March.		April.		May.		June.	
Day.	Long.	Lat.	Long.	Lat.	Long.	Lat.	Long.	Lat.	Long.	Lat.	Long.	Lat.
1	−15.0	−0.4	−15.3	+0.1	−14.5	+2.0	−8.3	−2.0	−6.4	−5.1	−8.4	−5.4
2	−12.4	−0.3	−13.1	−0.2	−13.5	+0.9	−8.2	−2.9	−6.6	−5.5	−9.1	−6.0
3	−10.0	+0.1	−11.5	−0.6	−12.6	−0.2	−8.2	−3.6	−7.4	−5.5	−9.5	−6.9
4	−8.1	+0.6	−11.1	−1.4	−11.6	−1.3	−8.9	−3.7	−8.4	−5.6	−9.2	−7.8
5	−7.5	+1.2	−10.7	−2.2	−11.2	−2.1	−9.0	−4.0	−8.7	−5.5	−7.0	−8.8
6	−7.9	+1.5	−10.0	−2.8	−10.7	−2.8	−7.7	−3.4	−7.1	−5.5	−3.4	−9.1
7	−8.7	+1.4	−8.3	−3.1	−10.2	−3.1	−5.6	−2.5	−3.2	−5.4	+0.4	−9.0
8	−8.2	+0.8	−5.3	−3.3	−8.3	−2.8	−1.5	−1.6	+1.8	−5.3	+1.0	−8.4
9	−7.3	−0.1	−2.7	−3.0	−5.6	−2.6	+3.6	−0.3	+6.4	−5.0	−1.3	−7.6
10	−5.4	−0.9	−1.1	−2.3	−2.3	−1.5	+7.1	+0.2	+8.5	−4.6	−7.2	−6.5
11	−3.6	−1.4	−2.3	−1.4	+0.9	−0.2	+8.1	+0.5	+5.5	−4.2	−15.3	−5.1
12	−3.5	−1.3	−6.6	−0.7	+1.7	+0.5	+4.9	+0.5	−1.7	−3.8	−21.9	−4.0
13	−5.9	−0.9	−11.6	−0.3	−0.1	+0.9	−1.5	+0.5	−10.0	−3.0	−24.3	−2.9
14	−10.1	−0.1	−15.0	−0.5	−4.0	+0.9	−9.1	+0.1	−16.1	−2.1	−22.1	−2.0
15	−15.3	+0.5	−15.7	−0.7	−8.5	+0.5	−14.4	+0.2	−17.5	−1.4	−17.2	−0.9
16	−18.5	+1.0	−14.5	−0.7	−12.4	−0.2	−15.9	+0.1	−15.4	−0.9	−12.3	+0.1
17	−18.4	+1.5	−12.6	−1.6	−15.0	−1.1	−14.0	+0.1	−11.7	−0.5	−8.9	+0.8
18	−15.6	+1.7	−10.9	−1.7	−15.7	−1.4	−11.4	+0.2	−9.2	+0.6	−8.1	+0.9
19	−11.6	+1.8	−11.1	−2.1	−14.7	−1.8	−10.8	+0.2	−8.5	+1.7	−8.2	+1.1
20	−9.5	+1.1	−12.8	−2.3	−13.6	−1.8	−12.5	+1.4	−8.7	+3.0	−8.3	+0.5
21	−9.8	+0.4	−15.7	−1.3	−14.0	−1.6	−15.3	+2.7	−9.1	+3.7	−8.4	−0.7
22	−12.3	−0.5	−18.2	0.0	−16.3	−0.6	−16.5	+4.2	−9.3	+3.6	−7.9	−1.9
23	−15.8	−0.7	−20.1	+1.5	−19.7	+1.0	−15.2	+4.6	−8.7	+3.2	−6.3	−3.0
24	−18.3	−0.5	−20.8	+2.9	−22.1	+2.9	−12.6	+4.6	−8.0	+1.6	−5.5	−3.5
25	−19.2	+0.3	−20.2	+3.3	−21.1	+3.7	−10.0	+3.6	−8.1	0.0	−5.4	−3.7
26	−19.6	+0.9	−18.0	+3.7	−17.8	+4.5	−8.7	+2.2	−8.2	−1.4	−6.0	−3.6
27	−19.7	+1.4	−16.0	+3.4	−14.0	+4.5	−8.3	+0.4	−8.3	−2.8	−6.9	−3.4
28	−20.1	+1.4	−15.2	+2.8	−10.5	+3.9	−8.5	−1.6	−8.2	−3.8	−8.0	−3.2
29	−20.4	+1.4	...	...	−9.3	+2.6	−8.1	−3.2	−7.7	−4.5	−9.2	−3.5
30	−19.3	+1.1	...	...	−9.0	+0.9	−7.3	−4.1	−7.4	−5.1	−10.2	−3.8
31	−17.5	+0.7	...	...	−8.8	−0.6	...	...	−7.8	−5.3	...	...

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1858. Day.	July. Long.	Lat.	August. Long.	Lat.	September. Long.	Lat.	October. Long.	Lat.	November. Long.	Lat.	December. Long.	Lat.
1	−10.9	−4.7	−15.6	−3.2	−15.4	−0.1	−15.2	+2.1	−13.3	+7.5	−10.0	+5.6
2	−12.1	−5.6	−16.9	−3.2	−13.3	+1.3	−14.2	+3.7	−12.6	+6.3	−9.9	+3.4
3	−12.8	−6.3	−15.3	−2.0	−11.3	+3.0	−13.5	+5.2	−14.5	+5.0	−12.0	+1.5
4	−12.7	−6.8	−11.6	−0.6	−11.3	+4.7	−14.2	+6.1	−18.5	+3.5	−16.0	0.0
5	−10.9	−6.8	−8.1	+1.0	−13.9	+6.6	−16.3	+6.4	−23.2	+1.7	−19.7	−1.2
6	−7.8	−5.9	−8.3	+2.5	−18.1	+8.1	−20.6	+5.9	−26.4	+0.1	−21.9	−1.9
7	−5.1	−5.0	−12.6	+4.1	−22.5	+8.6	−25.0	+4.9	−26.4	−1.6	−22.1	−2.3
8	−6.3	−3.6	−19.6	+5.6	−26.0	+8.5	−27.6	+3.3	−24.0	−2.9	−20.0	−1.9
9	−11.7	−2.3	−25.9	+6.6	−26.8	+7.3	−26.9	+1.4	−19.3	−3.4	−16.6	−1.6
10	−19.8	−0.8	−28.6	+7.2	−25.3	+5.2	−22.8	−0.5	−14.2	−3.8	−13.2	−1.5
11	−26.7	+0.3	−27.7	+6.3	−20.9	+3.0	−16.7	−1.7	−10.5	−4.2	−11.4	−1.9
12	−29.7	+1.2	−24.1	+4.9	−15.2	+0.7	−11.1	−2.5	−8.5	−4.6	−11.2	−2.5
13	−27.2	+1.5	−18.7	+2.7	−10.1	−1.0	−7.1	−3.1	−7.9	−5.4	−13.0	−3.4
14	−21.7	+1.3	−13.9	+0.8	−6.3	−2.4	−5.0	−3.8	−8.0	−6.2	−16.1	−4.1
15	−15.8	+0.6	−10.3	−1.3	−4.3	−3.2	−3.8	−4.5	−8.6	−7.1	−19.3	−4.9
16	−12.1	−0.1	−8.5	−3.1	−3.9	−3.9	−3.3	−5.1	−9.4	−7.6	−21.3	−4.4
17	−10.0	−1.0	−7.2	−4.4	−4.0	−4.5	−3.1	−5.7	−10.6	−7.5	−21.6	−3.6
18	−9.5	−2.5	−6.5	−5.2	−4.0	−4.6	−3.2	−6.3	−12.2	−6.7	−21.4	−2.5
19	−9.6	−3.5	−6.0	−5.6	−4.2	−4.7	−4.1	−6.3	−14.1	−5.5	−21.6	−1.2
20	−8.9	−4.7	−5.7	−5.8	−4.7	−4.6	−6.5	−6.0	−16.2	−3.8	−20.6	+0.2
21	−7.5	−5.1	−5.2	−5.3	−6.6	−4.3	−9.6	−5.0	−16.8	−2.1	−18.9	+1.1
22	−5.8	−5.6	−5.3	−4.7	−8.0	−3.6	−12.6	−3.8	−16.3	−0.2	−15.6	+2.3
23	−4.8	−5.3	−6.4	−3.8	−9.1	−2.8	−14.4	−2.8	−15.0	+1.2	−12.2	+3.5
24	−4.3	−4.8	−7.4	−3.0	−9.5	−2.4	−14.8	−1.4	−13.4	+3.2	−10.4	+4.6
25	−5.2	−3.7	−7.5	−2.5	−9.9	−2.1	−14.3	−0.3	−13.0	+5.3	−10.4	+5.5
26	−6.7	−3.0	−7.3	−2.0	−10.3	−2.0	−13.7	+0.7	−13.9	+7.3	−11.8	+5.7
27	−8.2	−2.5	−7.2	−2.1	−11.6	−1.6	−14.4	+1.9	−15.0	+8.9	−12.8	+4.8
28	−8.9	−2.2	−8.7	−2.5	−13.2	−1.4	−15.4	+3.4	−15.0	+9.3	−12.0	+3.3
29	−9.8	−2.5	−11.5	−2.2	−14.8	−0.9	−16.5	+5.0	−13.6	+8.9	−9.5	+1.3
30	−10.8	−2.8	−14.6	−2.1	−15.7	+0.5	−16.2	+6.4	−11.6	+7.3	−6.3	−0.3
31	−13.2	−3.2	−16.3	−1.6	...	...	−15.1	+7.3	...	...	−3.5	−1.8

HANSEN—BURCKHARDT.

1859. Day	January. Long. Lat.		February. Long. Lat.		March. Long. Lat.		April. Long. Lat.		May. Long. Lat.		June. Long. Lat.	
1	$-3''.1$	$-2''.5$	$+1''.4$	$-4''.4$	$+5''.8$	$-4''.3$	$+12''.2$	$-1''.3$	$+8''.4$	$-3''.5$	$-21''.2$	$-4''.9$
2	-4.8	-2.9	-2.4	-3.5	$+7.3$	-3.3	$+9.2$	-1.0	$+1.8$	-2.7	-28.6	-2.8
3	-8.7	-2.6	-6.6	-2.7	$+6.1$	-2.5	$+3.9$	-0.6	-5.4	-1.8	-31.5	-0.8
4	-12.9	-2.2	-9.4	-1.8	$+2.5$	-2.0	-1.0	-0.4	-12.1	-0.8	-29.7	$+0.6$
5	-15.9	-1.4	-10.2	-1.1	-1.8	-1.6	-4.9	-0.6	-17.3	-0.1	-23.9	$+2.1$
6	-16.3	-0.8	-8.8	-0.6	-4.9	-1.3	-8.0	-0.9	-19.3	$+0.8$	-17.9	$+2.8$
7	-14.9	-0.1	-6.7	-0.3	-6.1	-1.6	-10.8	-0.9	-19.4	$+1.5$	-14.1	$+3.4$
8	-11.8	$+0.6$	-4.9	-0.5	-6.1	-1.8	-14.4	-0.8	-18.7	$+2.9$	-13.0	$+3.7$
9	-9.2	$+0.7$	-5.3	-0.7	-6.2	-2.3	-18.1	-0.2	-18.1	$+4.2$	-12.8	$+2.9$
10	-8.5	$+0.5$	-8.0	-1.0	-7.8	-2.5	-21.8	$+1.1$	-18.3	$+5.3$	-12.4	$+1.9$
11	-10.1	$+0.1$	-12.2	-0.6	-11.5	-2.6	-23.8	$+2.9$	-18.7	$+6.2$	-11.5	$+0.6$
12	-13.7	-0.3	-17.1	$+0.4$	-16.1	-1.6	-24.1	$+4.9$	-17.8	$+6.0$	-10.6	-0.8
13	-18.1	-0.3	-20.8	$+1.5$	-20.2	0.0	-22.2	$+6.2$	-15.7	$+4.9$	-10.4	-1.5
14	-21.7	-0.2	-23.2	$+3.0$	-22.5	$+1.9$	-18.0	$+6.5$	-12.6	$+3.6$	-11.0	-2.2
15	-23.8	$+0.4$	-24.6	$+4.1$	-22.6	$+4.1$	-13.4	$+6.0$	-10.3	$+2.3$	-11.7	-2.7
16	-24.7	$+1.4$	-25.4	$+5.0$	-20.6	$+5.6$	-9.7	$+5.0$	-9.1	$+0.7$	-11.4	-2.8
17	-25.6	$+2.1$	-25.0	$+4.9$	-18.3	$+6.2$	-7.6	$+3.6$	-8.9	-0.4	-9.7	-2.8
18	-25.6	$+2.8$	-23.4	$+4.5$	-16.4	$+6.1$	-7.2	$+1.9$	-9.3	-1.7	-7.4	-2.5
19	-25.0	$+3.2$	-20.5	$+3.2$	-14.6	$+5.0$	-7.7	$+0.4$	-9.2	-2.5	-5.2	-2.9
20	-22.0	$+3.4$	-17.7	$+1.6$	-13.6	$+3.4$	-8.1	-1.1	-8.1	-3.4	-4.1	-3.5
21	-17.8	$+2.8$	-15.1	-0.4	-12.6	$+1.6$	-8.7	-2.6	-7.5	-4.1	-4.3	-4.3
22	-14.5	$+2.3$	-13.1	-2.0	-11.7	-0.2	-9.5	-3.8	-6.7	-5.3	-5.4	-5.7
23	-12.6	$+1.1$	-12.0	-3.8	-11.1	-1.9	-10.0	-4.7	-6.2	-6.4	-6.6	-6.6
24	-12.0	-0.3	-10.9	-5.0	-11.1	-3.3	-9.4	-5.6	-4.8	-7.5	-7.3	-7.2
25	-11.9	-2.0	-9.3	-6.2	-11.2	-4.2	-7.1	-6.1	-2.4	-8.2	-7.3	-7.8
26	-10.6	-3.5	-6.4	-6.5	-10.8	-4.9	-2.5	-6.0	$+0.4$	-9.0	-7.5	-7.8
27	-8.1	-4.8	-2.6	-6.2	-8.7	-5.2	$+3.7$	-5.6	$+3.2$	-9.0	-9.0	-7.8
28	-4.4	-6.0	$+1.9$	-5.2	-4.1	-4.9	$+9.4$	-5.3	$+4.0$	-8.8	-14.2	-7.0
29	-0.3	-6.0	...	...	$+1.9$	-4.0	$+12.7$	-4.7	$+2.3$	-8.4	-23.0	-5.5
30	$+2.4$	-5.9	...	...	$+8.0$	-2.9	$+12.3$	-4.1	-3.0	-7.6	-32.9	-3.4
31	$+3.2$	-5.3	...	...	$+12.0$	-2.1	...	...	-11.3	-6.6	...	...

HANSEN—BURCKHARDT.

1859. Day	July. Long.	Lat.	August. Long.	Lat.	September. Long.	Lat.	October. Long.	Lat.	November. Long.	Lat.	December. Long.	Lat.
1	−39.2	−1.4	−35.7	+4.9	−26.8	+3.9	−22.4	+0.7	−10.1	−3.8	−5.6	−3.8
2	−40.1	+0.4	−30.5	+3.8	−20.9	+2.3	−16.4	−0.5	−7.1	−4.2	−6.2	−4.2
3	−35.5	+1.7	−24.7	+2.6	−15.5	+0.7	−12.3	−1.3	−5.9	−4.8	−7.1	−4.2
4	−27.8	+1.8	−18.8	+0.9	−11.9	−0.5	−9.7	−2.3	−6.4	−5.4	−9.5	−4.0
5	−20.7	+1.8	−14.2	−0.7	−9.7	−1.7	−8.5	−2.9	−7.4	−5.7	−12.2	−4.1
6	−15.7	+1.2	−10.7	−2.4	−8.2	−2.6	−7.6	−3.8	−9.3	−5.9	−14.7	−3.8
7	−12.7	0.0	−8.2	−3.4	−6.7	−3.1	−7.0	−4.0	−12.3	−5.5	−17.6	−3.4
8	−10.6	−1.3	−6.3	−4.2	−5.3	−3.2	−7.2	−4.0	−16.0	−4.9	−20.0	−2.4
9	−8.9	−2.8	−4.9	−4.7	−4.4	−3.1	−8.9	−3.7	−19.2	−4.1	−21.7	−1.6
10	−7.6	−3.7	−4.1	−4.4	−4.5	−2.4	−11.8	−3.1	−20.2	−3.0	−22.8	−0.8
11	−6.7	−4.4	−3.7	−3.9	−6.3	−2.1	−15.0	−2.6	−19.7	−2.1	−22.4	+0.5
12	−7.0	−4.4	−3.8	−3.4	−8.5	−1.5	−16.6	−1.9	−17.9	−1.2	−20.7	+2.1
13	−7.8	−4.1	−4.3	−2.4	−10.3	−0.8	−15.9	−1.4	−16.4	+0.2	−19.0	+3.8
14	−8.4	−3.5	−5.2	−1.7	−11.4	−0.4	−13.8	−1.4	−15.9	+1.6	−18.8	+5.7
15	−8.5	−2.9	−6.3	−0.7	−11.7	−0.2	−12.2	−1.1	−16.4	+3.2	−19.8	+6.6
16	−7.6	−2.0	−7.3	−0.4	−11.3	−0.8	−12.4	−0.9	−17.8	+5.1	−21.9	+6.5
17	−6.2	−1.5	−9.0	0.0	−12.2	−1.2	−14.4	−0.2	−19.4	+6.3	−23.5	+5.6
18	−5.0	−1.2	−10.6	0.0	−14.3	−1.2	−16.8	+0.8	−20.2	+6.8	−22.7	+3.5
19	−5.2	−1.1	−12.8	−0.6	−16.3	−1.1	−17.5	+2.1	−20.1	+6.0	−19.2	+1.1
20	−7.0	−1.5	−14.8	−0.7	−16.6	−0.5	−16.4	+3.2	−19.3	+4.3	−14.6	−1.0
21	−9.6	−1.8	−16.0	−0.6	−14.4	+0.8	−14.4	+3.8	−18.3	+2.5	−11.4	−2.7
22	−12.3	−2.6	−15.4	−0.3	−11.0	+2.0	−13.9	+3.8	−18.2	+0.5	−11.0	−3.6
23	−14.0	−3.3	−13.0	0.0	−9.6	+3.5	−16.0	+3.4	−19.5	−1.0	−12.9	−4.1
24	−13.6	−2.9	−10.9	+1.1	−12.4	+5.0	−20.6	+2.7	−22.2	−2.3	−15.7	−4.4
25	−12.0	−2.8	−10.4	+2.6	−19.6	+6.0	−25.9	+2.0	−24.6	−3.2	−17.0	−3.8
26	−12.0	−2.6	−14.1	+4.5	−28.5	+6.3	−30.3	+0.8	−24.7	−3.9	−15.8	−3.2
27	−14.8	−1.4	−21.5	+6.5	−34.9	+5.9	−32.0	−0.1	−22.0	−3.9	−12.4	−2.3
28	−21.2	0.0	−29.6	+8.0	−36.9	+4.8	−31.1	−1.3	−17.1	−3.7	−8.7	−1.3
29	−29.3	+2.1	−35.2	+8.0	−34.5	+3.0	−27.1	−2.2	−11.7	−3.6	−6.0	−0.7
30	−35.5	+4.0	−35.8	+7.3	−29.0	+1.7	−21.1	−2.8	−7.6	−3.5	−5.2	−0.1
31	−38.0	+5.0	−32.6	+5.7	...	...	−15.0	−3.3	..	...	..6.4	−0.1

Comparison of Burckhardt's and Hansen's

HANSEN—BURCKHARDT.

1860. Day.	January. Long. Lat.		February. Long. Lat.		March. Long. Lat.		April. Long. Lat.		May. Long. Lat.		June. Long. Lat.	
1	−9.0	−0.2	−16.1	+1.1	−17.4	−0.5	−24.8	+3.7	−21.5	+5.4	−16.4	−0.5
2	−12.1	−0.3	−20.7	+1.3	−22.3	+0.5	−23.1	+4.9	−18.7	+4.7	−15.3	−1.3
3	−15.6	−0.2	−24.2	+1.6	−25.1	+1.7	−20.8	+5.3	−16.9	+3.8	−14.7	−1.5
4	−18.2	−0.3	−26.8	+2.2	−25.9	+2.8	−18.8	+5.1	−16.2	+3.1	−14.9	−1.6
5	−20.6	0.0	−28.3	+2.6	−25.8	+3.8	−17.4	+4.6	−15.1	+2.3	−14.6	−1.1
6	−23.2	+0.3	−29.5	+3.0	−24.9	+3.7	−15.8	+3.6	−13.7	+1.6	−13.4	−1.2
7	−25.6	+0.7	−28.8	+3.3	−24.1	+3.4	−14.0	+2.6	−13.6	+0.7	−10.9	−1.3
8	−27.1	+1.7	−26.2	+2.7	−22.4	+2.5	−12.1	+1.2	−13.6	−0.2	−8.6	−1.4
9	−26.9	+2.5	−23.0	+1.4	−19.1	+1.3	−10.8	0.0	−12.6	−1.5	−7.4	−1.4
10	−25.1	+3.4	−19.4	0.0	−14.7	0.0	−10.1	−1.3	−11.1	−2.8	−6.4	−1.8
11	−22.6	+3.5	−16.5	−1.6	−10.9	−1.6	−9.8	−3.0	−9.6	−4.0	−5.9	−2.1
12	−20.8	+3.2	−14.8	−3.6	−9.1	−3.2	−9.2	−4.2	−7.4	−4.8	−5.3	−2.5
13	−21.0	+2.4	−13.2	−5.3	−8.5	−4.3	−7.5	−5.4	−5.7	−5.1	−4.0	−2.6
14	−22.1	+1.2	−10.7	−6.9	−8.0	−5.7	−4.3	−5.5	−2.9	−4.7	−3.5	−3.3
15	−21.4	−1.0	−7.0	−8.0	−6.0	−6.6	+0.1	−5.3	+0.9	−4.1	−4.3	−3.9
16	−18.4	−3.2	−2.4	−8.4	−2.2	−6.9	+6.0	−4.5	+4.8	−3.8	−7.7	−4.3
17	−13.4	−5.0	+2.7	−8.0	+3.0	−6.3	+10.6	−3.7	+6.7	−3.8	−14.1	−4.6
18	−7.4	−6.4	+6.6	−7.1	+8.7	−5.4	+13.9	−2.7	+5.2	−4.1	−22.0	−4.2
19	−3.1	−7.1	+8.1	−6.1	+13.0	−4.4	+13.5	−1.9	+0.6	−3.6	−29.5	−3.6
20	−1.0	−6.9	+7.5	−4.7	+14.0	−3.0	+9.7	−1.3	−6.6	−3.3	−34.7	−2.3
21	−1.8	−6.6	+4.4	−3.5	+12.3	−2.0	+3.4	−1.1	−13.8	−2.8	−36.2	−1.0
22	−4.1	−5.4	+0.4	−2.6	+7.7	−1.3	−3.2	−1.0	−20.0	−1.9	−34.3	−0.1
23	−6.8	−4.4	−3.3	−1.7	+2.2	−0.9	−9.0	−0.9	−23.4	−1.0	−29.7	+0.5
24	−8.0	−3.1	−5.4	−1.0	−2.9	−0.7	−13.4	−0.5	−24.4	+0.6	−24.0	+0.7
25	−8.1	−1.4	−6.4	−0.3	−6.4	−1.0	−16.6	−0.1	−24.4	+1.8	−19.9	0.0
26	−7.3	−0.4	−6.5	−0.2	−9.1	−1.1	−20.3	+0.7	−23.0	+2.8	−17.2	−1.0
27	−6.3	+0.4	−6.4	−0.6	−11.7	−1.4	−23.0	+2.1	−21.8	+3.3	−16.0	−1.9
28	−5.9	+1.0	−8.7	−1.0	−14.8	−1.5	−24.8	+3.4	−20.8	+3.4	−15.7	−3.1
29	−6.4	+1.1	−12.4	−1.2	−18.8	−1.0	−25.3	+4.8	−20.1	+2.4	−15.2	−4.2
30	−8.6	+1.2	...	...	−22.9	+0.4	−23.9	+5.4	−19.7	+1.3	−14.9	−4.6
31	−12.0	+1.2	...	...	−25.2	+2.1	...	...	−18.1	+0.3	...	...

HANSEN—BURCKHARDT.

1860. Day.	July. Long.	Lat.	August. Long.	Lat.	September. Long.	Lat.	October. Long.	Lat.	November. Long.	Lat.	December. Long.	Lat.
1	−14.8	−4.4	−11.7	−2.5	−12.4	+2.0	−16.7	+3.5	−17.8	+1.5	−15.6	+0.9
2	−14.6	−3.9	−10.6	−1.0	−11.2	+3.0	−15.6	+3.2	−15.6	+1.1	−14.4	+1.9
3	−13.8	−3.1	−9.0	+1.0	−9.3	+3.5	−14.1	+2.8	−14.8	+1.3	−16.0	+2.3
4	−12.5	−2.1	−6.5	+2.0	−7.7	+3.2	−13.2	+1.9	−15.9	+2.0	−19.5	+2.5
5	−9.8	−0.8	−4.2	+2.9	−7.8	+2.8	−14.0	+1.9	−18.6	+3.1	−22.5	+2.1
6	−6.5	+0.2	−3.6	+3.3	−10.0	+2.2	−16.4	+1.7	−21.6	+3.2	−23.3	+0.7
7	−4.2	+1.2	−4.8	+3.4	−13.7	+2.1	−19.2	+2.3	−23.1	+2.3	−20.9	−1.3
8	−3.5	+1.7	−7.1	+3.0	−16.8	+1.9	−20.9	+2.9	−21.9	+0.9	−18.2	−3.8
9	−4.4	+1.9	−10.0	+2.3	−18.4	+2.2	−20.9	+3.0	−19.9	−0.9	−15.3	−5.7
10	−6.1	+1.6	−12.8	+1.8	−17.5	+2.7	−20.0	+2.8	−19.2	−3.0	−14.0	−7.0
11	−8.0	+1.1	−14.3	+1.3	−16.5	+2.7	−19.6	+2.2	−21.0	−4.6	−15.0	−7.7
12	−8.8	+0.3	−14.7	+1.0	−17.5	+3.1	−22.6	+0.9	−25.5	−5.8	−16.5	−8.0
13	−9.8	−0.7	−15.7	+1.0	−22.9	+3.4	−28.5	−0.1	−29.2	−6.6	−17.7	−7.8
14	−11.7	−1.7	−18.5	+1.0	−31.8	+3.3	−35.7	−1.3	−30.3	−7.0	−17.1	−7.0
15	−15.4	−2.3	−25.0	+1.8	−41.0	+3.2	−40.2	−2.3	−27.9	−7.2	−14.5	−5.6
16	−21.2	−2.5	−33.9	+2.3	−45.9	+2.3	−40.6	−3.2	−22.5	−6.8	−11.4	−4.2
17	−28.7	−2.1	−41.6	+3.1	−44.9	+1.4	−36.1	−4.2	−17.1	−6.1	−9.0	−2.4
18	−36.4	−1.0	−46.0	+2.8	−39.3	+0.6	−29.4	−4.5	−12.2	−5.0	−6.7	−0.8
19	−42.3	−0.1	−44.1	+2.3	−31.6	−0.1	−22.2	−4.3	−9.6	−4.3	−7.3	+0.7
20	−44.1	+0.6	−37.8	+1.5	−24.4	−0.7	−16.3	−4.4	−9.2	−3.2	−8.7	+1.9
21	−41.3	+0.6	−29.4	+0.9	−18.2	−1.3	−12.2	−4.4	−10.3	−1.9	−10.3	+2.6
22	−34.8	0.0	−22.3	0.0	−13.9	−2.1	−10.6	−4.1	−11.9	−0.6	−11.4	+3.4
23	−27.0	−0.3	−16.6	−0.5	−10.5	−2.3	−10.6	−3.8	−13.1	+0.6	−12.4	+3.6
24	−20.3	−0.9	−13.1	−1.2	−8.7	−2.4	−11.3	−2.4	−13.6	+1.6	−13.7	+3.5
25	−15.9	−1.8	−10.8	−1.8	−8.2	−2.2	−12.4	−1.1	−14.4	+2.0	−15.8	+3.2
26	−13.0	−2.6	−8.5	−2.2	−8.7	−1.2	−13.4	−0.1	−17.0	+1.8	−18.5	+2.7
27	−12.1	−3.5	−7.5	−2.5	−10.4	−0.2	−15.0	+0.9	−18.4	+1.8	−20.2	+2.1
28	−11.2	−4.2	−7.7	−2.0	−12.7	+0.9	−16.9	+1.8	−19.2	+1.4	−20.6	+1.7
29	−10.9	−4.3	−9.1	−1.7	−15.3	+2.0	−18.6	+2.1	−20.2	+1.2	−19.5	+1.4
30	−11.3	−4.2	−11.1	−0.5	−16.6	+2.8	−19.9	+2.5	−18.5	+1.1	−18.4	+1.2
31	−11.5	−3.6	−12.4	+0.7	...	...	−19.6	+2.1	...	...	−18.3	+1.1

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Comparison of Burckhardt's and Hansen's

HANSEN—BURCKHARDT.

1861. Day.	January. Long. Lat.		February. Long. Lat.		March. Long. Lat.		April. Long. Lat.		May. Long. Lat.		June. Long. Lat.	
1	−19.7	+0.7	−20.4	−5.4	−13.4	−6.1	−5.9	−6.9	−4.9	−4.3	−6.7	+2.0
2	−21.8	+0.2	−20.4	−7.2	−12.5	−7.2.	−3.8	−7.5	−3.6	−3.6	−4.9	+2.9
3	−23.4	−1.0	−18.7	−8.7	−12.1	−8.4	−0.8	−7.3	−1.6	−2.3	−2.4	+3.5
4	−23.5	−2.9	−14.4	−9.8	−10.4	−9.6	+3.2	−6.4	+1.3	−0.8	−0.2	+3.6
5	−21.5	−5.3	−7.9	−10.1	−5.9	−9.8	+7.4	−4.5	+4.5	+0.6	+0.2	+2.9
6	−18.0	−7.0	−0.7	−9.8	+0.6	−9.3	+10.8	−2.7	+7.4	+1.8	−1.3	+2.0
7	−13.3	−8.4	+4.3	−8.7	+7.0	−8.0	+12.6	−1.0	+8.3	+2.3	−5.7	+1.1
8	−8.7	−8.6	+5.8	−7.3	+11.4	−6.1	+12.2	+0.6	+6.3	+2.0	−11.8	+0.3
9	−5.7	−8.6	+4.1	−5.5	+12.7	−4.2	+9.3	+1.4	+1.6	+1.7	−17.4	−0.1
10	−5.1	−8.1	+1.3	−3.7	+10.8	−2.6	+4.5	+1.8	−4.8	+1.3	−20.8	−0.5
11	−6.2	−7.0	−1.1	−1.8	+7.4	−0.9	−1.1	+2.2	−11.2	+1.4	−22.3	−0.5
12	−7.6	−5.5	−2.3	+0.1	+3.4	+0.2	−6.2	+2.1	−15.8	+1.2	−22.3	−0.7
13	−8.1	−3.6	−2.7	+1.4	−0.2	+1.2	−10.5	+2.1	−18.3	+1.2	−22.1	−0.6
14	−7.2	−1.5	−3.4	+2.1	−2.6	+1.8	−13.5	+1.7	−18.8	+1.6	−21.7	−0.9
15	−6.3	+0.4	−5.2	+2.5	−5.0	+1.8	−15.5	+2.2	−18.9	+1.9	−21.4	−1.5
16	−5.9	+2.0	−7.9	+2.8	−7.6	+1.8	−16.9	+2.6	−19.7	+2.5	−19.9	−2.5
17	−6.5	+3.2	−11.2	+3.1	−10.6	+1.7	−18.1	+3.2	−21.0	+2.6	−18.1	−3.7
18	−7.9	+3.7	−14.0	+3.1	−13.4	+1.9	−19.6	+4.3	−21.7	+2.2	−16.7	−5.0
19	−10.3	+4.3	−16.7	+3.4	−16.2	+2.4	−20.3	+4.6	−21.3	+1.6	−16.4	−6.2
20	−12.3	+4.5	−18.0	+3.3	−18.1	+3.0	−20.3	+4.6	−19.2	+0.3	−16.7	−6.9
21	−14.2	+4.3	−17.9	+3.3	−18.7	+3.7	−19.1	+4.2	−17.5	−1.0	−17.0	−7.2
22	−16.2	+4.1	−17.9	+2.7	−18.3	+3.9	−17.8	+2.8	−17.9	−2.1	−16.5	−6.9
23	−17.7	+3.5	−18.3	+1.8	−17.3	+3.6	−17.8	+1.2	−19.3	−3.0	−15.6	−5.8
24	−19.0	+3.2	−19.8	+0.5	−16.9	+2.7	−18.3	0.0	−20.4	−3.4	−14.0	−4.5
25	−20.4	+2.3	−21.4	−1.1	−17.1	+1.1	−19.1	−0.9	−19.9	−3.3	−12.4	−2.8
26	−21.5	+1.6	−21.2	−2.4	−17.8	−0.4	−18.6	−1.7	−17.7	−3.0	−10.7	−0.8
27	−22.6	+0.7	−19.0	−4.0	−17.2	−1.9	−16.2	−2.5	−14.4	−2.7	−9.4	+1.1
28	−23.2	−0.3	−15.6	−5.0	−15.2	−3.0	−12.4	−3.2	−11.5	−2.1	−8.4	+2.6
29	−22.5	−1.6	...	...	−12.2	−3.9	−8.8	−3.8	−9.3	−1.2	−7.6	+3.7
30	−21.4	−2.7	...	...	−9.6	−5.0	−6.3	−4.3	−8.5	−0.2	−7.5	+4.8
31	−20.5	−4.0	...	...	−7.5	−5.9	...	...	−7.9	+1.0	...	...

HANSEN—BURCKHARDT.

1861.	July.		August.		September.		October.		November.		December.	
Day.	Long.	Lat.	Long.	Lat.	Long.	Lat.	Long.	Lat.	Long.	Lat.	Long.	Lat.
1	−7.2	+5.3	−7.8	+3.4	−16.0	+4.3	−26.5	+4.0	−30.8	−4.0	−19.8	−8.7
2	−6.2	+4.8	−9.4	+2.9	−21.6	+4.2	−32.8	+2.8	−36.2	−6.0	−23.5	−9.6
3	−5.4	+3.8	−12.2	+2.3	−29.8	+3.7	−40.4	+0.7	−39.3	−7.8	−24.3	−9.8
4	−6.0	+2.8	−17.1	+1.9	−38.7	+2.5	−46.7	−1.3	−38.3	−8.7	−22.2	−8.8
5	−8.5	+1.8	−24.1	+1.5	−45.7	+1.1	−49.0	−3.3	−33.2	−9.3	−18.7	−7.6
6	−12.9	+0.7	−31.2	+0.6	−47.8	0.0	−45.8	−4.7	−26.5	−9.0	−15.5	−5.7
7	−18.5	+0.1	−36.2	0.0	−44.1	−1.0	−38.7	−5.5	−20.8	−8.5	−13.7	−3.4
8	−23.6	−0.6	−38.4	+0.5	−36.5	−1.2	−30.0	−6.3	−16.7	−7.3	−13.0	−1.3
9	−27.2	−0.9	−36.4	+0.9	−27.7	−1.6	−22.1	−6.6	−14.8	−5.6	−13.1	+1.2
10	−28.6	−1.4	−31.2	−1.2	−20.6	−2.0	−16.6	−6.6	−13.8	−3.5	−13.7	+3.1
11	−28.5	−1.8	−24.7	−1.1	−16.1	−2.5	−13.3	−6.1	−13.1	−1.2	−13.5	+4.7
12	−26.7	−2.3	−19.3	−1.1	−13.2	−2.8	−11.7	−5.0	−12.4	+0.9	−12.7	+5.5
13	−23.7	−2.7	−16.2	1.6	−12.2	−3.4	−11.5	−3.7	−11.5	+2.2	−11.5	+5.8
14	−20.3	−3.1	−15.1	−2.3	−12.2	−3.2	−11.7	−1.8	−11.4	+3.3	−10.9	+5.4
15	−17.5	−3.8	−15.1	−3.6	−13.3	−2.7	−12.9	0.0	−12.3	+3.8	−11.2	+4.5
16	−15.6	−4.9	−15.2	−4.6	−15.9	−1.7	−14.7	+1.4	−13.9	+3.8	−12.4	+3.8
17	−15.4	−6.1	−15.6	−5.0	−18.4	−0.4	−16.8	+2.7	−16.0	+3.4	−14.0	+2.7
18	−16.2	−7.2	−16.4	−4.8	−20.4	+0.9	−18.4	+3.6	−16.8	+2.8	−14.7	+1.7
19	−16.1	−7.8	−17.9	−3.8	−21.1	+2.1	−18.8	+3.9	−16.2	+2.0	−14.4	+0.6
20	−15.4	−8.0	−18.8	−2.6	−18.9	+3.1	−17.2	+3.9	−14.4	+1.4	−12.4	−0.1
21	−14.7	−7.1	−18.2	−1.0	−14.5	+3.5	−14.4	+3.4	−12.2	+0.6	−11.4	−0.8
22	−14.2	−5.8	−15.7	+0.6	−10.0	+3.3	−11.4	+2.9	−11.4	+0.6	−11.3	−0.9
23	−13.5	−3.8	−11.2	+1.9	−6.6	+3.1	−9.7	+2.5	−12.5	+0.7	−12.8	−1.3
24	−12.2	−1.6	−6.6	+2.8	−5.6	+3.1	−10.1	+2.7	−15.8	+0.6	−14.8	−2.1
25	−9.8	+0.3	−3.9	+2.9	−7.2	+3.3	−13.0	+3.4	−19.2	+0.1	−15.2	−3.1
26	−7.0	+1.9	−3.6	+2.8	−10.6	+4.1	−17.2	+4.0	−20.9	−0.8	−13.1	−4.6
27	−5.5	+3.2	−5.1	+3.0	−14.0	+4.9	−21.6	+4.1	−19.5	−2.4	−9.6	−6.0
28	−5.0	+3.9	−7.6	+3.4	−17.3	+5.6	−24.5	+3.5	−16.6	−4.0	−6.5	−7.1
29	−5.6	+4.2	−9.8	+3.6	−19.9	+5.8	−25.3	+2.1	−14.9	−5.5	−5.1	−8.2
30	−6.6	+4.3	−11.4	+4.2	−22.5	+5.2	−25.2	+0.3	−16.2	−7.1	−6.1	−8.9
31	−7.2	+4.0	−13.0	+4.4	...	...	−26.5	−1.8	...	...	−8.4	−9.0

HANSEN—BURCKHARDT.

1862.	January.		February.		March.		April.		May.		June.	
Day.	Long.	Lat.	Long.	Lat.	Long.	Lat.	Long.	Lat.	Long.	Lat.	Long.	Lat.
1	−10.3	−8.4	−4.0	−3.5	+5.8	−2.7	−4.7	+2.7	−12.7	+3.6	−17.6	+0.3
2	−11.4	−7.0	−5.1	−1.7	+1.6	−1.4	−7.4	+3.4	−13.3	+3.6	−17.4	−0.6
3	−11.2	−5.0	−6.0	+0.2	−1.6	+0.1	−8.9	+3.8	−13.0	+3.4	−16.8	−1.3
4	−10.4	−2.5	−7.4	+1.5	−4.2	+1.1	−9.9	+4.0	−12.6	+3.4	−16.5	−1.6
5	−9.5	−0.4	−9.6	+2.8	−6.5	+1.9	−10.5	+4.3	−12.5	+3.2	−16.6	−2.1
6	−9.5	+1.6	−12.1	+3.8	−9.2	+2.7	−10.5	+5.0	−12.7	+3.3	−17.1	−2.5
7	−10.7	+3.7	−14.0	+4.5	−11.2	+3.4	−10.3	+5.2	−13.1	+3.1	−17.3	−3.3
8	−12.7	+5.0	−14.2	+5.1	−12.4	+4.1	−9.5	+5.4	−13.4	+2.7	−17.6	−4.1
9	−14.1	+6.2	−12.8	+5.3	−11.8	+4.5	−8.6	+5.0	−13.4	+2.1	−18.2	−5.1
10	−14.5	+6.6	−10.7	+4.8	−10.0	+4.6	−7.6	+4.3	−13.7	+1.2	−19.4	−6.2
11	−13.4	+6.4	−9.1	+4.2	−7.8	+4.3	−7.1	+3.2	−15.4	+0.1	−20.8	−6.9
12	−11.8	+6.2	−9.0	+3.4	−6.2	+3.6	−8.0	+1.7	−18.5	−1.1	−21.4	−7.3
13	−10.8	+5.3	−10.1	+2.0	−5.8	+26	−11.1	0.0	−22.2	−2.7	−20.8	−6.7
14	−11.4	+4.3	−11.6	+0.4	−6.6	+0.9	−15.6	−2.1	−24.8	−4.0	−18.6	−5.4
15	−12.3	+3.3	−12.8	−1.1	−8.7	−0.9	−19.5	−4.2	−24.1	−5.2	−15.4	−3.6
16	−13.4	+2.1	−13.5	−2.6	−11.4	−2.7	−21.0	−5.9	−20.6	−5.5	−12.9	−1.6
17	−13.8	+0.7	−14.6	−3.6	−14.2	−4.5	−19.1	−7.5	−16.3	−5.1	−10.8	+0.8
18	−13.0	−0.3	−15.8	−4.6	−16.4	−6.4	−15.8	−8.4	−12.4	−4.2	−8.8	+2.8
19	−12.5	−1.2	−17.7	−5.6	−17.5	−7.7	−12.7	−9.0	−9.7	−3.1	−7.5	+4.6
20	−12.8	−1.8	−19.2	−7.0	−17.2	−9.1	−10.5	−8.8	−7.5	−1.1	−6.2	+5.7
21	−14.3	−2.6	−19.0	−8.4	−16.5	−10.4	−8.2	−7.8	−5.1	+0.7	−4.8	+6.4
22	−16.3	−3.3	−16.3	−9.7	−15.3	−11.2	−5.4	−5.7	−2.5	+2.8	−3.0	+6.6
23	−16.4	−4.8	−10.9	··10.2	−12.9	−11.1	−1.5	−3.3	+0.1	+4.4	−1.8	+6.0
24	−14.3	6.4	−3.8	−10.2	−8.5	−10.3	+2.7	−1.0	+1.4	+5.3	−1.6	+5.2
25	−9.5	−7.7	+3.6	−9.1	−2.7	−8.3	+5.6	+1.4	+1.7	+5.5	−2.9	+4.0
26	−3.9	−8.9	+8.8	−7.8	+3.5	−6.1	+6.0	+2.8	−0.3	+5.4	−6.2	+2.7
27	+1.3	−9.3	+10.7	−6.1	+8.5	−3.7	+3.2	+3.5	−3.9	+4.5	−10.9	+1.5
28	+4.1	−9.1	+9.2	−4.4	+10.1	−1.5	−1.5	+3.8	−8.3	+3.8	−15.9	+0.3
29	+4.0	−8.3	...	...	+8.3	0.0	−6.6	+4.0	−12.4	+2.9	−19.8	−0.9
30	+1.8	−7.1	...	...	+4.2	+1.4	−10.5	+3.8	−15.5	+2.1	−21.8	−1.9
31	−1.3	−5.5	...	...	−0.7	+2.0	...	...	−17.2	+1.2	...	...

HANSEN—BURCKHARDT.

1862. Day.	July. Long.	Lat.	August. Long.	Lat.	September. Long.	Lat.	October. Long.	Lat.	November. Long.	Lat.	December. Long.	Lat.
1	−22·0	−2·7	−22·7	−1·2	−17·8	−1·3	−15·5	−4·2	−16·3	−1·3	−11·9	+3·6
2	−20·9	−3·4	−22·1	−1·5	−16·8	−2·1	−17·4	−3·7	−14·6	+0·4	−10·1	+4·0
3	−20·0	−3·8	−20·9	−2·3	−17·8	−3·2	−19·7	−2·4	−13·7	+1·7	−9·3	+4·1
4	−19·5	−4·2	−19·4	−3·9	−20·7	−3·9	−21·4	−0·9	−14·5	+2·5	−9·6	+3·4
5	−19·3	−4·8	−17·7	−5·3	−23·8	−3·7	−22·4	+0·3	−16·0	+2·8	−10·9	+2·7
6	−18·7	−5·9	−17·1	−7·0	−26·2	−3·3	−23·2	+1·3	−17·2	+2·7	−12·1	+1·5
7	−17·2	−7·2	−17·9	−8·2	−27·7	−2·5	−24·0	+2·4	−16·8	+2·2	−12·1	+0·2
8	−15·9	−8·6	−20·1	−8·3	−27·7	−1·8	−23·5	+2·7	−13·5	+1·2	−10·9	−1·2
9	−15·3	−9·7	−22·1	−8·1	−26·3	−0·9	−20·8	+2·6	−9·1	+0·2	−9·0	−2·7
10	−16·1	−10·1	−23·1	−6·9	−23·1	−0·6	−15·7	+2·1	−5·1	−0·5	−7·3	−3·5
11	−17·4	−9·8	−22·4	−5·7	−18·3	−0·4	−9·8	+1·7	−3·1	−1·1	−6·7	−4·0
12	−18·3	−8·7	−20·1	−4·0	−12·9	+0·1	−4·5	+1·2	−4·0	−1·2	−7·6	−4·0
13	−17·8	−6·8	−17·1	−2·9	−8·2	+0·3	−2·2	+1·5	−7·2	−0·8	−9·6	−3·7
14	−16·1	−4·7	−13·7	−1·7	−5·5	+0·8	−2·7	+1·7	−11·5	−0·7	−12·0	−3·6
15	−13·8	−2·3	−10·8	−0·7	−4·9	+1·4	−6·1	+2·3	−15·5	−0·6	−13·7	−3·7
16	−11·8	−0·4	−9·2	+0·2	−6·2	+2·0	−10·6	+2·9	−17·9	−0·5	−13·8	−3·7
17	−10·3	+1·6	−8·3	+0·9	−8·5	+2·7	−15·5	+3·3	−18·8	−1·0	−12·7	−4·1
18	−9·6	+2·9	−7·7	+2·0	−11·5	+3·5	−19·6	+3·2	−19·7	−1·4	−12·1	−4·3
19	−8·8	+4·0	−7·2	+2·6	−15·8	+3·8	−23·6	+2·7	−22·3	−2·4	−13·2	−5·2
20	−7·8	+4·4	−7·5	+3·0	−21·7	+3·8	−27·8	+2·1	−27·1	−3·5	−16·6	−6·0
21	−6·3	+4·7	−8·9	+3·1	−28·6	+3·4	−33·3	+1·0	−32·6	−5·0	−20·5	−6·1
22	−4·6	+4·5	−12·9	+2·7	−35·9	+2·5	−39·7	−0·6	−36·2	−6·4	−22·7	−5·6
23	−3·6	+3·7	−19·2	+2·6	−41·7	+1·7	−45·2	−2·4	−36·3	−7·1	−21·9	−4·5
24	−4·9	+3·1	−26·2	+2·1	−45·3	+0·4	−47·2	−4·3	−33·3	−7·2	−19·1	−2·8
25	−8·8	+2·0	−32·1	+1·4	−44·8	−0·8	−44·4	−5·9	−28·9	−6·5	−16·0	−1·2
26	−14·9	+1·3	−34·8	+0·8	−40·7	−1·8	−37·6	−7·1	−24·9	−5·2	−14·2	+0·8
27	−20·7	+0·2	−34·5	+0·4	−33·7	−2·7	−30·1	−7·7	−22·0	−3·2	−13·7	+2·4
28	−24·7	−0·5	−31·6	+0·3	−25·8	−3·4	−24·0	−7·6	−20·0	−1·2	−14·3	+4·2
29	−26·4	−0·9	−27·7	+0·2	−19·1	−4·1	−20·7	−6·9	−17·4	+0·6	−14·1	+5·4
30	−25·5	−1·4	−23·8	+0·2	−15·6	−4·3	−19·2	−5·3	−14·6	+2·5	−13·2	+6·2
31	−24·1	−1·2	−20·3	−0·3	...	...	−18·1	−3·3	...	...	−11·3	+6·6
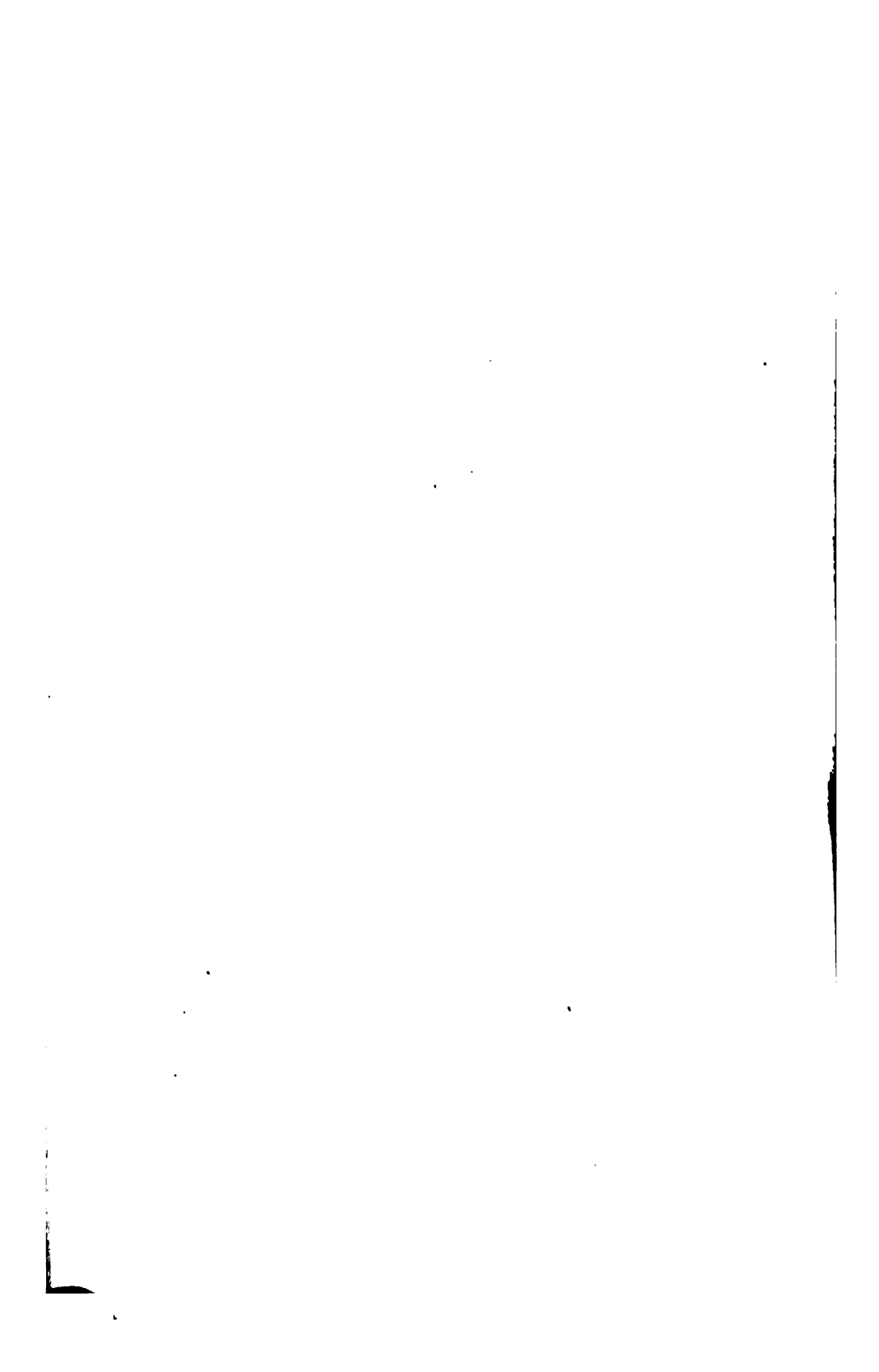
COMPARISON OF

HANSEN'S LUNAR TABLES

WITH OBSERVATIONS MADE AT THE

ROYAL OBSERVATORY, GREENWICH

IN THE YEARS

1847–61

Note by the Astronomer Royal.

The arrangement of the following computations is very simple, and almost explains itself.

Column 1 is the Greenwich mean solar time of observation. For the Transit Circle Observations this is taken from the section "Right Ascensions and North Polar Distances of the Centre of the Moon," in the volumes for the several years. For the Altazimuth Observations, the time given is the mean, to the nearest minute, of the several times of observation (generally four) of the limbs in azimuth and zenith distance. These times do not appear in the printed volumes, but are extracted from the MS. computations preserved at the Observatory.

Columns 2 and 6 are taken, for the years 1847 to 1858, from the section "Errors of the Moon's Tabular Places in Longitude and Ecliptic North Polar Distance, as deduced from the Tables of Burckhardt and Hansen, compared with the results of observations made at the Royal Observatory from 1847 to 1858," in the volume of Greenwich Observations for 1859. For subsequent years the numbers in columns 2 and 6 are taken from the section "Errors of the Moon's Tabular Place in Longitude and Ecliptic North Polar Distance," in the annual volumes of Greenwich Observations.

Column 3 contains the sum of two corrections, the necessity for which was pointed out by Mr. Marth, and which are fully explained by Professor Adams. For the Altazimuth Observations, only one of these is applicable, due to the change of solar tables; and this may be taken, without sensible error, as constant.

For the Transit Circle Observations a table of double entry was formed, with arguments Moon's hourly motion in longitude, and observed error of right ascension, to give at once the sum of the two corrections, of which one was taken constant.

Columns 4 and 7 are formed by simple interpolation, for the time of observation, between the calculated values of $H-B$ (see pp. 8-39) for the preceding and following midnights. Column 5, Error of Hansen's Tables in Longitude, is the algebraical sum of columns 2, 3, and 4; and column 8, Error of Hansen's Tables in E.N.P.D., is the sum of columns 6 and 7.

All the work was practically done independently in duplicate. For the earlier years (1847-1855 Transit Circle, and 1847-1853 Altaz.), the duplication of the figures was not actual; a com-

parison was really made between the present computations and others founded on the Errors of Burckhardt printed in the annual volumes ; but a complete check on both computations was readily secured, and this comparison allowed of the detection of several mistakes in both the printed series of Errors of Burckhardt. The mistakes in the series of Errors printed in the annual volumes 1847 to 1858 have not been very carefully investigated, as these figures are now entirely superseded. But the following is a complete list of all such mistakes in the collected results for the years 1847 to 1858, given in the volume for 1859, and of those in subsequent years discovered by a careful scrutiny of the Errors.

Errata in the Collected Results for 1847 to 1858 (Greenwich Observations, 1859).

Page.	Date.	for	Old Values. Longitude. B-O.	H-O.	E.N.P.D. B-O.	H-O.	read	New Values. Longitude. B-O.	H-O.	E.N.P.D. B-O.	H-O.
94	1847 Sept. 1	for	+ 4·7	− 3·0	+ 4·0	+ 1·9	read	+ 5·8	− 1·9	− 4·0	− 6·1
,,	Sept. 21	for	+ 6·1	− 1·0	− 4·5	− 6·1	read	+ 1·4	− 5·7	+ 7·0	+ 5·4
,,	Nov. 10	for	+24·8	+ 3·7	− 2·6	− 2·6	read	+23·8	+ 2·7	+ 0·2	+ 0·2
,,	Nov. 22	for	...	...	− 3·3	+ 0·3	read	...	...	+ 3·3	+ 6·9
95	Dec. 19	for	+ 1·8	− 6·1	− 1·8	− 4·8	read	+ 2·8	− 5·1	+ 3·0	0·0
,,	1848 Feb. 16	for	...	...	+ 2·8	+ 7·9	read	...	...	− 2·8	+ 2·3
,,	June 11	for	...	...	+ 1·8	+ 8·8	read	...	...	− 4·1	+ 2·9
96	Dec. 17	for	+ 9·9	+ 6·5	+ 0·2	+ 7·9	read	+ 5·9	+ 2·5	− 9·0	− 1·3
,,	Mar. 7	for	...	...	− 4·6	+ 0·5	read	...	...	+ 4·6	+ 9·7
,,	Mar. 29	for	+ 0·9	+ 4·2	+ 9·4	+11·1	read	− 5·3	− 2·0	+ 7·8	+ 9·5
,,	May 24	for	...	...	− 4·3	− 9·3	read	...	...	+ 4·3	− 0·7
98	1849 Aug. 3	for	(− 3·3)	(− 4·2)	(+25·1)	(+21·4)	read	+ 2·0	+ 1·1	+ 5·8	+ 2·1
99	Oct. 28	for	+ 4·5	+ 2·2	+ 4·0	− 3·9	read	+ 2·2	− 0·1	+ 9·1	+ 1·2
100	May 26	for	+ 4·4	− 3·4	− 6·5	− 2·6	read	+ 5·9	− 1·9	− 0·8	+ 3·1
,,	June 30	for	+ 2·4	− 3·8	− 2·3	− 2·4	read	− 3·2	− 9·4	− 0·7	− 0·8
,,	July 2	for	− 0·9	− 2·6	− 3·7	− 6·4	read	+ 0·2	− 1·5	+ 4·4	+ 1·7
,,	July 10	for	...	...	− 4·4	− 8·5	read	...	...	+ 4·4	+ 0·3
101	1850 Jan. 1	for	+10·9	+ 4·1	+ 0·6	+ 7·9	read	+ 7·8	+ 1·0	− 7·7	− 0·4
102	Feb. 19	for	− 7·0	−11·4	− 4·2	− 4·0	read	− 8·1	−12·5	+ 1·2	+ 1·4
,,	Feb. 20	for	+ 0·5	− 8·4	− 6·5	− 5·1	read	− 0·2	− 9·1	− 0·7	+ 0·7
,,	Mar. 17	for	+ 1·6	+ 0·1	− 3·6	− 4·1	read	− 0·7	− 2·2	+ 3·8	+ 3·3

Page	Date		Old Values					New Values			
			Longitude B–O	Longitude H–O	E.N.P.D. B–O	E.N.P.D. H–O		Longitude B–O	Longitude H–O	E.N.P.D. B–O	E.N.P.D. H–O
			″	″	″	″		″	″	″	″
105	1851 Oct. 8	for	...	...	– 5·6	– 5·1	read	...	...	+ 2·5	+3·0
„	Oct. 30	for	...	...	– 0·3	– 5·5	read	...	...	+ 3·3	–1·9
106	Feb. 22	for	+ 1·1	– 2·8	– 3·2	– 6·3	read	+ 2·0	– 1·9	+ 2·6	–0·5
„	Aug. 21	for	+12·3	+ 2·2	– 7·3	– 3·1	read	+10·3	+ 0·2	– 9·7	–5·5
„	Aug. 22	for	+11·2	+ 1·5	–12·8	– 7·6	read	+ 8·0	– 1·7	– 9·9	–4·7
108	1852 Aug. 29	for	+13·8	– 1·9	...	...	read	+16·9	+ 1·2	...	...
„	Jan. 18	for	+ 0·9	+ 1·2	+11·5	+ 3·4	read	– 1·6	– 1·3	+11·4	+3·3
111	1853 Sept. 17	for	+18·7	– 2·9	...	...	read	+22·2	+ 0·6	...	...
113	Sept. 9	for	+12·5	– 0·7	– 6·7	– 5·8	read	+13·2	0·0	– 2·5	–1·6
115	1854 July 14	for	...	...	– 7·9	–10·3	read	...	...	+ 3·8	+1·4
116	Nov. 4	for	+ 2·5	– 8·5	...	...	read	+12·5	+ 1·5	...	...
128	1858 Dec. 24	for	...	...	– 3·2	– 7·8	read	...	...	+ 3·2	–1·4

Errata in Subsequent Years.

(The following errors are all in observations made with the Altazimuth.)

Date		Old Values Long.	Old Values E.N.P.D.		New Values Long.	New Values E.N.P.D.
			″			″
1859 Mar. 13	for	...	–4·27	read	...	+4·27
Mar. 14	for	...	–1·93	read	...	+1·93
Mar. 15	for	...	–4·91	read	...	+4·91
Mar. 21	for	...	–0·46	read	...	+0·46

Date		Old Values Long.	Old Values E.N.P.D.		New Values Long.	New Values E.N.P.D.
		″	″		″	″
1859 Apr. 10	for	...	–2·77	read	...	+2·77
Oct. 21	for	...	–1·45	read	...	+1·45
1860 Dec. 19	for	+ 6·66	...	read	+2·91	...
1861 Oct. 23	for	+16·34	+1·66	read	+1·60	+1·14

ERRORS OF

HANSEN'S LUNAR TABLES

IN

LONGITUDE AND ECLIPTIC NORTH POLAR DISTANCE

AS DEDUCED FROM OBSERVATIONS MADE WITH THE

TRANSIT CIRCLE

AT THE

ROYAL OBSERVATORY, GREENWICH

IN THE YEARS

1847–61

Errors of Hansen's Tables deduced from Observations made with the Transit Circle.

Approx. G.M.T. 1847.			Longitude.				E.N.P.D.		
d	h	m	B−O	Corr. to B.	H−B	H−O	B−O	H−B	H−O
Jan. 1	12	22	+ 2·8	−0·4	− 1·9	+0·5	+0·2	+0·5	+0·7
5	15	25	− 0·2	−0·4	+ 1·4	+0·8	−4·9	+4·6	−0·3
10	19	2	+ 6·8	−0·6	− 4·5	+1·7	−9·0	+7·1	−1·9
23	5	59	+ 4·8	−0·5	− 6·7	−2·4	+4·3	−5·4	−1·1
24	6	51	+ 3·5	−0·5	− 7·1	−4·1	+2·9	−5·4	−2·5
28	10	17	− 2·1	−0·2	+ 1·9	−0·4	+0·1	+1·1	+1·2
29	11	5	− 2·2	−0·2	+ 3·3	+0·9	−1·6	+2·7	+1·1
31	12	38	− 0·3	−0·3	+ 1·6	+1·0	−3·7	+4·3	+0·6
Feb. 4	15	28	+ 4·4	−0·5	− 0·2	+3·7	−5·3	+4·4	−0·9
6	16	56	+ 4·3	−0·5	− 1·5	+2·3	−7·9	+4·9	−3·0
7	17	42	+ 5·1	−0·5	− 2·7	+1·9	−6·1	+5·3	−0·8
8	18	31	+ 4·5	−0·5	− 3·5	+0·5	−4·4	+5·4	+1·0
19	3	52	+10·2	−0·8	−12·5	−3·1	+2·7	−5·3	−2·6
24	8	14	+ 5·4	−0·5	− 5·0	−0·1	−0·2	+2·6	+2·4
25	9	3	+ 3·2	−0·4	− 1·6	+1·2	−2·0	+4·8	+2·8
26	9	50	− 1·6	−0·2	+ 1·5	−0·3	−4·6	+6·6	+2·0
28	11	19	− 2·6	−0·2	+ 4·2	+1·4	−5·3	+7·6	+2·3
Mar. 3	13	27	+ 6·2	−0·5	− 3·0	+2·7	−5·6	+6·6	+1·0
7	16	26	+ 6·6	−0·6	− 3·8	+2·2	−6·9	+5·8	−1·1
9	18	8	+ 5·2	−0·5	− 1·7	+3·0	−5·6	+4·9	−0·7
10	19	2	− 1·4	−0·3	+ 0·5	−1·2	−8·6	+4·0	−4·6
24	6	59	+ 5·1	−0·5	− 7·5	−2·9	−1·0	+3·5	+2·5
25	7	47	+ 9·5	−0·6	− 7·8	+1·1	−2·2	+6·2	+4·0
26	8	33	+ 7·1	−0·5	− 6·9	−0·3	−5·0	+8·0	+3·0
27	9	18	+ 5·7	−0·5	− 4·9	+0·3	−7·5	+9·4	+1·9
29	10	43	+ 4·5	−0·5	− 0·2	+3·8	−5·8	+9·4	+3·6
30	11	25	− 0·3	−0·4	− 0·2	−0·9	−9·4	+9·0	−0·4
Apr. 8	18	44	+ 6·4	−0·6	− 1·7	+4·1	−6·4	+2·4	−4·0
22	6	29	+ 7·0	−0·6	− 7·3	−0·9	−6·3	+5·0	−1·3
23	7	14	+12·1	−0·7	−10·1	+1·3	−5·8	+7·1	+1·3
24	7	58	+12·6	−0·7	−11·7	+0·2	−7·1	+8·7	+1·6
25	8	41	+13·7	−0·8	−11·2	+1·7	−9·2	+9·4	+0·2
27	10	5	+ 4·9	−0·5	− 4·8	−0·4	−7·9	+9·0	+1·1
28	10	49	+ 1·1	−0·4	− 2·0	−1·3	−6·0	+7·9	+1·9
29	11	34	+ 3·9	−0·5	− 1·1	+2·3	−5·7	+6·8	+1·1
30	12	20	+ 4·7	−0·5	− 2·8	+1·4	−5·1	+5·8	+0·7
May 4	15	46	+ 9·9	−0·7	− 9·6	−0·4	+2·7	+1·0	+3·7
6	17	33	+13·6	−0·9	− 9·9	+2·8	+0·6	−1·1	−0·5

e

Approx. G.M.T. 1847.			Longitude.				E.N.P.D		
d	h	m	B−O	Corr. to B.	H−B	H−O	B−O	H−B	H−O
May 21	5	54	+ 6.3	−0.5	− 7.3	−1.5	− 3.5	+ 5.8	+ 2.3
22	6	37	+13.6	−0.8	− 9.8	+3.0	− 8.5	+ 7.7	− 0.8
25	8	44	+ 8.3	−0.6	− 7.9	−0.2	− 6.7	+10.0	+ 3.3
26	9	28	+ 6.4	−0.6	− 4.3	+1.5	− 8.9	+ 9.5	+ 0.6
27	10	15	+ 2.8	−0.5	− 1.7	+0.6	− 7.9	+ 8.4	+ 0.5
28	11	3	+ 1.9	−0.4	− 1.3	+0.2	− 7.0	+ 6.9	− 0.1
29	11	54	+ 2.5	−0.4	− 2.1	0.0	− 2.4	+ 4.9	+ 2.5
30	12	47	+ 7.1	−0.6	− 4.0	+2.5	− 2.9	+ 3.0	+ 0.1
31	13	41	+ 3.7	−0.4	− 5.7	−2.4	− 1.1	+ 1.3	+ 0.2
June 1	14	36	+ 7.0	−0.6	− 7.4	−1.0	+ 2.0	− 0.3	+ 1.7
2	15	30	+10.7	−0.8	− 9.1	+0.8	+ 4.6	− 1.6	+ 3.0
6	19	0	+ 9.3	−0.8	− 5.5	+3.0	+ 8.6	− 8.0	+ 0.6
19	5	15	+ 5.4	−0.5	− 7.0	−2.1	− 4.2	+ 5.6	+ 1.4
22	7	22	+ 5.8	−0.6	− 5.6	−0.4	− 7.4	+ 9.1	+ 1.7
23	8	7	+ 1.9	−0.4	− 4.2	−2.7	− 7.5	+ 9.8	+ 2.3
27	11	31	+ 5.2	−0.5	− 7.1	−2.4	− 7.0	+ 6.7	− 0.3
July 4	17	49	+ 9.4	−0.8	− 6.7	+1.9	+ 4.9	− 5.9	− 1.0
5	18	41	+ 6.8	−0.7	− 3.8	+2.3	+ 6.9	− 7.0	− 0.1
21	6	46	+ 3.3	−0.4	− 5.0	−2.1	− 3.5	+ 7.2	+ 3.7
22	7	34	+ 4.5	−0.5	− 6.1	−2.1	− 8.5	+ 7.8	− 0.7
23	8	24	+ 7.5	−0.6	− 7.4	−0.5	− 4.0	+ 8.1	+ 4.1
25	10	13	+14.7	−0.9	−10.6	+3.2	− 5.6	+ 7.6	+ 2.0
26	11	9	+12.0	−0.8	−12.7	−1.5	− 3.4	+ 6.3	+ 2.9
27	12	6	+14.1	−0.9	−14.0	−0.8	+ 2.5	+ 5.1	+ 7.6
29	13	58	+17.4	−0.9	−13.9	+2.6	− 7.0	+ 1.8	− 5.2
30	14	52	(+ 9.0)	−1.0	−11.5	(−3.5)	(+14.7)	− 0.1	(+14.6)
31	15	45	+12.6	−0.9	− 8.2	+3.5	+ 1.4	− 1.5	− 0.1
Aug. 1	16	38	+ 5.0	−0.6	− 5.2	−0.8	+ 3.9	− 3.1	+ 0.8
2	17	31	(+ 4.5)	−0.7	− 4.1	(−0.3)	(+15.7)	− 3.9	(+11.8)
3	18	25	+ 5.4	−0.6	− 4.4	+0.4	+ 4.6	− 3.8	+ 0.8
20	7	5	+ 7.7	−0.6	−10.7	−3.6	− 2.3	+ 3.2	+ 0.9
21	7	58	+ 9.1	−0.7	−11.8	−3.4	− 1.7	+ 3.2	+ 1.5
23	9	49	+10.0	−0.7	−11.7	−2.4	− 1.9	+ 3.0	+ 1.1
26	12	39	+17.3	−1.1	−14.0	+2.2	+ 4.4	+ 0.3	+ 4.7
27	13	34	+16.5	−1.1	−12.8	+2.6	+ 3.6	− 1.1	+ 2.5

Approx. G.M.T. 1847.			Longitude.			E.N.P.D.		
d h m		B–O	Corr. to B.	H–B	H–O	B–O	H–B	H–O
Aug. 29 15 24		+ 10ʺ4	– 0ʺ9	– 7ʺ2	+ 2ʺ3	+ 8ʺ0	– 3ʺ4	+ 4ʺ6
31 17 14		+ 8·9	– 0·8	– 6·6	+ 1·5	+ 5·3	– 3·0	+ 2·3
Sept. 1 18 9		+ 8·2	– 0·7	– 7·3	+ 0·2	+ 2·6	– 1·7	+ 0·9
3 19 55		+ 10·8	– 0·7	– 5·8	+ 4·3	– 2·0	+ 2·3	+ 0·3
18 6 41		+ 15·7	– 1·0	– 11·5	+ 3·2	+ 3·5	– 0·8	+ 2·7
22 10 21		+ 5·2	– 0·6	– 5·8	– 1·2	+ 0·9	– 2·2	– 1·3
23 11 17		+ 4·8	– 0·6	– 6·3	– 2·1	+ 2·9	– 3·0	– 0·1
24 12 13		+ 10·8	– 0·9	– 7·7	+ 2·2	+ 5·3	– 4·1	+ 1·2
26 14 7		+ 10·5	– 1·0	– 9·4	+ 0·1	+ 11·5	– 5·1	+ 6·4
27 15 4		+ 15·7	– 1·1	– 9·9	+ 4·7	+ 4·9	– 4·4	+ 0·5
28 16 1		+ 13·6	– 1·0	– 10·3	+ 2·3	+ 5·1	– 3·1	+ 2·0
Oct. 18 7 12		+ 5·5	– 0·6	– 7·1	– 2·2	+ 2·0	– 1·8	+ 0·2
19 8 6		+ 2·4	– 0·5	– 5·7	– 3·8	+ 1·6	– 2·2	– 0·6
20 9 0		+ 2·9	– 0·5	– 3·4	– 1·0	+ 2·1	– 2·9	– 0·8
21 9 54		+ 0·3	– 0·5	– 1·2	– 1·4	+ 5·4	– 3·5	+ 1·9
22 10 50		– 0·3	– 0·4	– 1·2	– 1·9	+ 4·5	– 4·5	0·0
24 12 46		+ 9·8	– 0·9	– 6·8	+ 2·1	+ 5·0	– 5·1	– 0·1
25 13 44		+ 14·4	– 1·0	– 9·1	+ 4·3	+ 2·8	– 3·9	– 1·1
26 14 43		+ 15·9	– 1·1	– 9·9	+ 4·9	+ 1·9	– 2·3	– 0·4
29 17 25		+ 14·2	– 0·9	– 7·5	+ 5·8	– 3·7	+ 3·6	– 0·1
30 18 14		+ 7·9	– 0·6	– 6·7	+ 0·6	– 4·9	+ 5·1	+ 0·2
Nov. 1 19 44		+ 6·2	– 0·6	– 5·2	+ 0·4	– 11·8	+ 7·1	– 4·7
18 8 35		+ 5·2	– 0·6	– 5·6	– 1·0	+ 4·3	– 2·9	+ 1·4
19 9 30		+ 2·5	– 0·5	– 3·7	– 1·7	+ 3·8	– 3·6	+ 0·2
23 13 22		+ 9·9	– 0·8	– 6·9	+ 2·2	– 0·4	– 1·5	– 1·9
24 14 20		+ 13·1	– 0·9	– 7·4	+ 4·8	– 0·8	– 0·1	– 0·9
27 16 54		+ 6·0	– 0·6	– 4·4	+ 1·0	– 3·8	+ 4·7	+ 0·9
28 17 40		+ 9·1	– 0·7	– 4·3	+ 4·1	– 6·6	+ 6·0	– 0·6
30 19 6		+ 7·3	– 0·7	– 4·8	+ 1·8	– 11·9	+ 8·1	– 3·8
Dec. 1 19 48		+ 7·7	– 0·7	– 4·5	+ 2·5	– 11·3	+ 8·7	– 2·6
13 4 47		+ 7·2	– 0·5	– 7·7	– 1·0	– 1·0	+ 1·2	+ 0·2
14 5 38		+ 5·6	– 0·5	– 7·4	– 2·3	+ 1·7	+ 0·4	+ 2·1
16 7 21		+ 8·5	– 0·7	– 9·0	– 1·2	+ 4·0	– 2·3	+ 1·7
19 10 7		+ 4·6	– 0·5	– 8·3	– 4·2	– 1·4	– 3·0	– 4·4
28 17 44		+ 3·6	– 0·5	– 2·7	+ 0·4	– 4·5	+ 5·8	+ 1·3
31 19 53		+ 3·2	– 0·5	– 3·0	– 0·3	– 5·8	+ 6·6	+ 0·8

Approx. G.M.T. 1848.			Longitude.				R.N.P.D.		
d	h	m	B−O	Corr. to B.	H−B	H−O	B−O	H−B	H−O
Jan. 12	5	19	+6″.1	−0″.6	− 8″.8	− 3″.3	+ 3″.3	− 2″.4	+ 0″.9
15	7	59	+8·5	−0·7	−11·8	−4·0	+4·5	−3·0	+1·5
16	8	55	+7·4	−0·6	−11·9	−5·1	+0·8	−1·7	−0·9
26	17	4	+2·4	−0·4	− 1·8	+0·2	−5·2	+4·3	−0·9
Feb. 12	6	50	+4·7	−0·5	−11·9	−7·7	+1·5	−2·6	−1·1
14	8	40	+8·3	−0·6	−11·5	−3·8	+1·1	+2·0	+3·1
15	9	34	+7·2	−0·6	− 8·2	−1·6	−2·7	+3·7	+1·0
16	10	26	+3·4	−0·4	− 5·0	−2·0	−2·8	+5·0	+2·2
17	11	16	+2·6	−0·4	− 3·1	−0·9	−3·7	+5·4	+1·7
18	12	3	+1·8	−0·4	− 3·3	−1·9	−4·4	+5·6	+1·2
20	13	33	+2·2	−0·4	− 4·9	−3·1	−5·9	+5·2	−0·7
22	14	59	+3·4	−0·5	− 2·9	0·0	−5·9	+4·2	−1·7
27	18	47	+0·8	−0·4	− 1·1	−0·7	−2·7	+2·9	+0·2
28	19	37	−0·3	−0·3	+ 0·9	+0·3	+1·8	+2·8	+4·6
Mar. 11	5	41	+7·7	−0·7	− 9·8	−2·8	+2·6	−1·2	+1·4
14	8	22	+4·7	−0·5	− 8·6	−4·4	−4·6	+5·2	+0·6
18	11	30	+3·8	−0·5	− 3·3	0·0	−6·8	+7·6	+0·8
19	12	13	+5·5	−0·6	− 4·0	+0·9	−9·3	+6·9	−2·4
21	13	39	+7·6	−0·6	− 5·3	+1·7	−5·4	+4·9	−0·5
Apr. 10	6	19	−0·6	−0·3	− 3·7	−4·6	−0·9	+3·0	+2·1
14	9	28	+6·2	−0·6	− 6·6	−1·0	−7·0	+8·5	+1·5
17	11	37	+1·8	−0·4	− 3·5	−2·1	−5·4	+6·1	+0·7
18	12	20	+6·3	−0·6	− 4·4	+1·3	−6·0	+4·7	−1·3
19	13	4	+4·1	−0·5	− 5·7	−2·1	−2·5	+2·9	+0·4
25	17	55	+7·7	−0·7	− 4·9	+2·1	+3·9	−1·6	+2·3
May 7	4	9	−1·4	−0·3	− 1·2	−2·9	−0·9	−0·6	−1·5
8	5	3	−0·2	−0·3	− 0·4	−0·9	+0·4	+1·3	+1·7
9	5	54	−1·2	−0·3	− 2·0	−3·5	−4·5	+3·3	−1·2
10	6	41	+3·2	−0·5	− 5·1	−2·4	−3·5	+5·4	+1·9
11	7	27	+7·3	−0·6	− 7·8	−1·1	−7·1	+7·1	0·0
12	8	10	+9·3	−0·7	− 9·1	−0·5	−6·4	+8·1	+1·7
13	8	53	+7·7	−0·6	− 8·5	−1·4	−6·1	+8·4	+2·3
14	9	35	+5·6	−0·5	− 6·3	−1·2	−6·0	+7·8	+1·8
15	10	18	+5·3	−0·5	− 3·8	+1·0	−3·5	+6·4	+2·9
16	11	2	+2·2	−0·4	− 2·1	−0·3	−0·9	+4·8	+3·9
18	12	34	+3·6	−0·4	− 2·7	+0·5	+2·5	+1·0	+3·5
20	14	11	+7·8	−0·6	− 6·1	+1·1	+3·1	−1·8	+1·3

Approx. G.M.T. 1848.			B−O	Longitude. Corr. to B.	H−B	H−O	R.N.P.D. B−O	H−B	H−O
	d	h	m							
May 22	15	52	+ 9·3	−0·7	− 8·8	−0·2	+5·0	− 3·6	+1·4
23	16	42	+ 12·3	−0·8	− 9·7	+1·8	+4·3	− 4·2	+0·1
24	17	32	+15·2	−1·0	−10·0	+4·2	+7·1	− 5·2	+1·9
June 5	3	45	+ 7·5	−0·6	− 6·6	+0·3	+3·4	− 0·7	+2·7
6	4	35	+ 4·2	−0·5	− 6·4	−2·7	−0·1	+ 1·1	+1·0
7	5	22	− 0·4	−0·3	− 6·5	−7·2	−3·5	+ 3·0	−0·5
11	8	16	+ 7·1	−0·5	− 8·8	−2·2	−4·1	+ 7·0	+2·9
13	9	44	+ 4·5	−0·4	− 4·4	−0·3	−0·6	+ 4·7	+4·1
15	11	18	− 0·1	−0·3	− 1·0	−1·4	+1·1	+ 2·0	+3·1
21	16	20	+13·7	−0·9	−11·3	+1·5	+5·7	− 4·1	+1·6
July 5	4	1	+ 9·1	−0·6	−12·1	−3·6	+1·2	+ 2·6	+3·8
6	4	46	+ 8·3	−0·6	− 9·1	−1·4	−1·9	+ 3·1	+1·2
11	8	25	+ 4·0	−0·4	− 6·1	−2·5	−1·4	+ 2·5	+1·1
12	9	12	+ 6·0	−0·5	− 5·1	+0·4	−0·1	+ 1·9	+1·8
13	10	1	− 0·3	−0·3	− 4·8	−5·4	+0·6	+ 1·4	+2·0
15	11	43	+ 4·6	−0·5	− 6·4	−2·3	+0·6	+ 1·0	+1·6
16	12	34	+11·5	−0·7	− 7·9	+2·9	−2·5	+ 1·0	−1·5
17	13	26	+11·2	−0·8	− 8·6	+1·8	+4·2	+ 0·4	+4·6
18	14	17	+13·9	−0·9	− 8·8	+4·2	+2·5	− 0·4	+2·1
20	15	58	+ 7·4	−0·6	− 9·3	−2·5	−1·5	− 2·8	−4·3
21	16	49	+12·9	−0·9	−10·2	+1·8	+5·3	− 3·7	+1·6
Aug. 4	4	7	+ 3·8	−0·4	− 8·6	−5·2	−2·3	+ 3·1	+0·8
5	4	50	+ 2·6	−0·4	− 4·9	−2·7	−1·4	+ 2·0	+0·6
10	8	42	+ 2·4	−0·4	− 5·2	−3·2	+0·5	− 0·8	−0·3
16	13	53	+12·2	−0·9	− 8·6	+2·7	+3·2	− 0·8	+2·4
17	14	45	+13·2	−0·9	− 7·7	+4·6	−0·3	− 1·6	−1·9
18	15	38	+10·6	−0·8	− 7·5	+2·3	−0·4	− 2·1	−2·5
19	16	31	+12·3	−0·9	− 8·4	+3·0	+0·9	− 2·4	−1·5
22	19	18	+12·5	−0·8	−10·6	+1·1	+0·4	+ 2·1	+2·5
Sept. 4	4	58	+ 0·4	−0·3	− 3·0	−2·9	+1·3	− 1·1	+0·2
6	6	32	− 1·9	−0·2	− 2·2	−4·3	+5·4	− 2·4	+3·0
8	8	13	− 1·5	−0·3	− 3·3	−5·1	+9·2	− 2·7	+6·5
11	10	49	+ 3·9	−0·5	− 5·3	−1·9	+2·2	− 2·2	0·0
12	11	42	+ 8·5	−0·7	− 6·4	+1·4	+5·3	− 2·2	+3·1
14	13	29	+12·0	−0·9	− 9·0	+2·1	+4·1	− 2·4	+1·7
15	14	24	+15·7	−1·1	− 9·9	+4·7	+4·1	− 2·2	+1·9
16	15	20	+15·4	−1·0	−10·3	+4·1	+2·2	− 1·7	+0·5
17	16	16	+14·4	−1·0	−10·5	+2·9	+1·1	− 1·1	0·0
18	17	14	+14·0	−1·0	−10·9	+2·1	−0·4	+ 0·5	+0·1
19	18	11	+17·1	−1·1	−11·2	+4·8	−2·1	+ 2·0	−0·1
20	19	6	+19·1	−1·1	−11·0	+7·0	−8·1	+ 3·7	−4·4

Approx. G.M.T. 1848.			Longitude.				E.N.P.D.		
			B−O	Corr. to B.	H−B	H−O	B−O	H−B	H−O
d h m									
Oct. 3	4	26	+ 3˙3	−0˙4	− 6˙7	−3˙8	− 5˙3	− 3˙5	−8˙8
5	6	3	+ 4˙3	−0˙5	− 3˙8	0˙0	+ 8˙3	− 4˙2	+4˙1
6	6	53	+ 7˙0	−0˙6	− 3˙6	+2˙8	+ 3˙5	− 4˙3	−0˙8
8	8	34	+ 1˙9	−0˙5	− 2˙1	−0˙7	+ 6˙5	− 4˙5	+2˙0
9	9	26	+ 0˙1	−0˙4	− 0˙8	−1˙1	+ 5˙3	− 4˙5	+0˙8
10	10	19	+ 1˙9	−0˙5	− 0˙4	+1˙0	+ 2˙8	− 4˙2	−1˙4
11	11	13	+ 4˙7	−0˙6	− 2˙1	+2˙0	+ 3˙8	− 4˙1	−0˙3
12	12	9	+12˙0	−0˙9	− 5˙7	+5˙4	+ 5˙4	− 3˙7	+1˙7
14	14	5	+10˙7	−0˙9	−10˙9	−1˙1	+ 6˙6	− 1˙2	+5˙4
18	17	56	+15˙1	−0˙9	−10˙6	+3˙6	− 4˙4	+ 5˙8	+1˙4
Nov. 4	6	24	+ 8˙7	−0˙6	− 8˙6	−0˙5	− 1˙1	− 4˙3	−5˙4
5	7	14	+ 9˙9	−0˙7	− 9˙0	+0˙2	+ 4˙7	− 5˙0	−0˙3
7	8	56	+ 4˙8	−0˙7	− 6˙7	−2˙6	+ 8˙2	− 5˙5	+2˙7
9	10	46	+ 6˙9	−0˙7	− 6˙1	+0˙1	+ 3˙5	− 3˙8	−0˙3
10	11	45	+ 4˙3	−0˙6	− 7˙5	−3˙8	− 0˙1	− 2˙4	−2˙5
12	13	47	+ 8˙8	−0˙8	− 7˙9	+0˙1	− 2˙4	+ 0˙9	−1˙5
14	15	47	+10˙0	−0˙8	− 4˙9	+4˙3	− 4˙9	+ 4˙8	−0˙1
15	16	42	+ 6˙9	−0˙7	− 4˙9	+1˙3	− 7˙1	+ 6˙6	−0˙5
17	18	23	+11˙6	−0˙9	− 6˙0	+4˙7	−10˙4	+10˙0	−0˙4
18	19	10	+ 7˙8	−0˙8	− 5˙3	+1˙7	−13˙4	+10˙9	−2˙5
20	20	37	+ 7˙3	−0˙6	− 3˙3	+3˙4	− 7˙4	+ 9˙9	+2˙5
Dec. 1	4	20	+ 6˙6	−0˙5	−12˙4	−6˙3	− 0˙2	− 0˙6	−0˙8
2	5	9	+ 6˙8	−0˙5	−10˙8	−4˙5	− 0˙5	− 0˙7	−1˙2
3	5	57	+10˙5	−0˙7	−11˙2	−1˙4	+ 1˙0	− 1˙7	−0˙7
4	6	46	+12˙3	−0˙8	−13˙3	−1˙8	+ 2˙8	− 2˙5	+0˙3
5	7	37	+11˙8	−0˙8	−15˙3	−4˙3	+ 1˙1	− 3˙3	−2˙2
6	8	30	+12˙2	−0˙9	−15˙9	−4˙6	+ 2˙8	− 3˙1	−0˙3
9	11	24	+ 7˙6	−0˙7	−11˙3	−4˙4	− 1˙1	+ 0˙6	−0˙5
10	12	27	+ 9˙6	−0˙8	− 9˙7	−0˙9	− 2˙4	+ 1˙5	−0˙9
11	13	28	+ 6˙1	−0˙6	− 7˙7	−2˙2	− 2˙0	+ 2˙7	+0˙7
12	14	28	+ 4˙5	−0˙6	− 4˙6	−0˙7	− 4˙9	+ 3˙0	−1˙9
13	15	24	+ 1˙8	−0˙5	− 2˙4	−1˙1	− 8˙0	+ 4˙7	−3˙3
17	18	35	+ 5˙9	−0˙6	− 3˙5	+1˙8	− 9˙0	+ 7˙7	−1˙3
20	20	45	+ 6˙3	−0˙5	− 3˙7	+2˙1	− 2˙4	+ 4˙6	+2˙2
21	21	30	+ 7˙1	−0˙6	− 3˙2	+3˙3	− 5˙4	+ 3˙0	−2˙4

Approx. G.M.T. 1849.			Longitude.				E.N.P.D.		
	d h m	B−O	Corr. to B.	H−B	H−O		B−O	H−B	H−O
Jan.	2 6 22	+ 5˙6	−0˙5	−10˙2	− 5˙1		+ 0˙9	+0˙2	+1˙1
	6 10 6	+ 7˙4	−0˙7	−14˙5	− 7˙8		− 2˙0	+2˙4	+0˙4
	8 12 8	+10˙5	−0˙8	−12˙7	− 3˙0		− 2˙7	+4˙3	+1˙6
	10 14 2	+12 7	−0˙8	−11˙0	+ 0˙9		− 3˙1	+4˙6	+1˙5
	14 17 14	+ 6˙2	−0˙5	− 5˙3	+ 0˙4		− 3˙4	+3˙8	+0˙4
	15 17 58	+ 8˙8	−0˙6	− 5˙6	+ 2˙6		− 4˙0	+3˙0	−1˙0
	17 19 26	+ 9˙0	−0˙6	− 5˙5	+ 2˙9		− 1˙6	+0˙8	−0˙8
	28 3 30	+ 2˙8	−0˙3	− 7˙9	− 5˙4		− 4˙6	0˙0	−4˙6
	31 6 3	+ 1˙0	−0˙3	− 7˙5	− 6˙8		− 1˙3	+0˙2	−1˙1
Feb.	4 9 52	+ 8˙4	−0˙7	−14˙0	− 6˙3		− 4˙0	+5˙7	+1˙7
	8 13 31	+11˙4	−0˙8	−12˙4	− 1˙8		− 7˙9	+6˙4	−1˙5
	10 15 6	+13˙3	−0˙8	−10 3	+ 2˙2		− 5˙7	+4˙5	−1˙2
	11 15 51	+10˙1	−0˙6	− 9˙0	+ 0˙5		− 3˙3	+3˙3	0˙0
	12 16 35	+ 6˙6	−0˙5	− 8˙1	− 2˙0		− 1˙1	+1˙9	+0˙8
	13 17 20	+ 7˙1	−0˙5	− 7˙7	− 1˙1		− 0˙3	+0˙6	+0˙3
	16 19 38	(+ 3˙3)	−0˙4	− 3˙3	− 0˙4		(+11˙6)	−2˙1	(+9˙5)
	17 20 26	(+ 1˙8)	−0˙3	− 0˙2	+ 1˙3		(− 1˙1)	−2˙0	(−3˙1)
	27 3 59	+ 6˙2	−0˙6	− 9˙5	− 3˙7		+ 3˙8	−1˙0	+2˙8
Mar.	1 5 49	+ 2˙8	−0˙4	− 9˙2	− 6˙8		− 0˙2	+0˙2	0˙0
	2 6 46	+ 1˙3	−0˙4	−11˙2	−10˙3		− 3˙2	+1˙8	−1˙4
	4 8 41	+11˙6	−0˙8	−15˙8	− 5˙0		− 5˙3	+6˙1	+0˙8
	5 9 37	+ 9˙7	−0˙7	−15˙5	− 6˙5		− 6˙4	+7˙8	+1˙4
	8 12 10	+ 8˙5	−0˙7	− 7˙7	+ 0˙1		− 5˙2	+8˙0	+2˙8
	9 12 57	+ 6˙4	−0˙6	− 7˙0	− 1˙2		− 5˙2	+6˙6	+1˙4
	10 13 43	+ 8˙1	−0˙7	− 7˙1	+ 0˙3		− 8˙1	+5˙0	−3˙1
	16 18 18	+ 6˙3	−0˙5	− 4˙9	+ 0˙9		+ 1˙2	−2˙4	−1˙2
	31 6 37	+ 3˙1	−0˙5	− 9˙6	− 7˙0		− 7˙2	+4˙3	−2˙9
Apr.	1 7 32	+11˙0	−0˙7	−12˙6	− 2˙3		− 3˙0	+6˙1	+3˙1
	2 8 25	+12˙0	−0˙8	−14˙1	− 2˙9		− 5˙7	+7˙7	+2˙0
	5 10 52	+ 2˙2	−0˙5	− 6˙4	− 4˙7		− 7˙3	+8˙0	+0˙7
	6 11 37	+ 1˙1	−0˙4	− 4˙4	− 3˙7		− 8˙1	+6˙5	−1˙6
	7 12 22	+ 5˙2	−0˙5	− 3˙9	+ 0˙8		− 5˙6	+4˙6	−1˙0
	8 13 7	+ 8˙9	−0˙6	− 4˙3	+ 4˙0		− 0˙8	+2˙3	+1˙5
	11 15 24	+ 4˙0	−0˙4	− 2˙9	+ 0˙7		+ 4˙2	−2˙9	+1˙3
	13 16 59	+ 4˙2	−0˙5	− 3˙4	+ 0˙3		+ 7˙4	−3˙9	+3˙5
	15 18 35	+ 8˙4	−0˙6	− 2˙4	+ 5˙4		+ 3˙2	−4˙0	−0˙8
	16 19 23	+ 4˙4	−0˙5	+ 1˙1	+ 5˙0		+ 5˙5	−3˙7	+1˙8
	27 4 30	+ 3˙6	−0˙6	− 5˙4	− 2˙4		−11˙0	+4˙0	−7˙0
	28 5 28	+ 1˙5	−0˙5	− 4˙1	− 3˙1		− 6˙1	+5˙0	−1˙1

Approx. G.M.T. 1849.			Longitude.			E.N.P.D.		
d h m	B−0	Corr. to B.	H−B	H−0	B−0	H−B	H−0
May 3 9 35	+ 3·3	− 0·5	− 6·0	− 3·2	− 7·9	+ 7·9	0·0
4 10 20	+ 3·3	− 0·4	− 4·8	− 1·9	− 4·5	+ 6·0	+ 1·5
5 11 4	+ 3·6	− 0·4	− 4·3	− 1·1	− 4·4	+ 3·8	− 0·6
7 12 34	+ 4·1	− 0·4	− 4·7	− 1·0	− 0·3	− 0·4	− 0·7
26 4 15	+ 4·9	− 0·5	− 8·5	− 4·1	− 2·5	+ 3·6	+ 1·1
27 5 9	− 1·1	− 0·3	− 5·3	− 6·7	− 2·7	+ 4·8	+ 2·1
29 6 48	− 0·7	− 9·4	− 3·9	− 5·0	− 7·8	+ 7·1	− 0·7
31 8 19	+ 2·9	− 0·4	− 5·5	− 3·0	− 6·3	+ 6·5	+ 0·2
June 1 9 3	+ 3·1	− 0·4	− 5·5	− 2·8	− 4·5	+ 4·6	+ 0·1
2 9 47	+ 4·3	− 0·5	− 5·0	− 1·2	− 1·9	+ 2·9	+ 1·0
3 10 32	+ 5·1	− 0·4	− 4·0	+ 0·7	− 3·1	+ 1·1	− 2·0
11 16 48	+ 7·2	− 0·6	− 6·4	+ 0·2	+ 7·7	− 6·7	+ 1·0
13 18 22	+ 4·0	− 0·6	− 6·3	− 2·9	+ 15·9	− 8·5	+ 7·4
24 3 52	+ 9·3	− 0·7	− 14·5	− 5·9	− 5·8	+ 4·2	− 1·6
27 6 17	+ 3·2	− 0·4	− 5·8	− 3·0	− 0·7	+ 3·9	+ 3·2
July 4 11 36	+ 1·2	− 0·3	− 0·2	+ 0·7	+ 5·0	− 3·4	+ 1·6
5 12 24	+ 3·0	− 0·4	− 0·9	+ 1·7	+ 5·1	− 3·3	+ 1·8
6 13 12	+ 6·0	− 0·5	− 3·0	+ 2·5	+ 4·1	− 3·2	+ 0·9
7 13 59	+ 8·8	− 0·6	− 5·1	+ 3·1	+ 4·6	− 3·1	+ 1·5
8 14 46	+ 13·4	− 0·8	− 6·0	+ 6·6	+ 6·9	− 3·4	+ 3·5
9 15 33	+ 6·3	− 0·5	− 7·2	− 1·4	+ 3·5	− 3·8	− 0·3
10 16 20	+ 9·8	− 0·7	− 8·4	+ 0·7	+ 6·4	− 4·2	+ 2·2
11 17 7	+ 12·3	− 0·7	− 10·0	+ 1·6	+ 4·3	− 4·9	− 0·6
24 4 10	+ 8·7	− 0·7	− 13·5	− 5·5	− 3·5	+ 5·9	+ 2·4
28 7 11	+ 7·4	− 0·4	− 5·7	+ 1·3	+ 3·2	− 1·8	+ 1·4
29 7 57	+ 5·8	− 0·4	− 4·9	+ 0·5	+ 5·3	− 3·6	+ 1·7
30 8 44	+ 5·3	− 0·4	− 3·5	+ 1·4	+ 7·5	− 4·8	+ 2·7
31 9 31	+ 1·2	− 0·3	− 1·8	− 0·9	+ 6·4	− 5·1	+ 1·3
Aug. 1 10 19	+ 3·2	− 0·4	− 0·7	+ 2·1	+ 6·7	− 5·0	+ 1·7
3 11 56	+ 2·0	− 0·4	− 1·3	+ 0·3	+ 5·8	− 3·7	+ 2·1
4 12 44	+ 6·2	− 0·6	− 2·8	+ 2·8	+ 6·3	− 3·2	+ 3·1
6 14 18	+ 7·0	− 0·6	− 4·5	+ 1·9	+ 4·0	− 2·6	+ 1·4
8 15 53	+ 10·4	− 0·7	− 7·7	+ 2·0	+ 2·7	− 2·4	+ 0·3
11 18 28	+ 12·6	− 0·8	− 12·0	− 0·2	+ 1·1	+ 0·4	+ 1·5
24 5 6	+ 8·5	− 0·5	− 7·5	+ 0·5	+ 0·7	+ 1·8	+ 2·5
29 9 1	+ 3·4	− 0·4	− 0·6	+ 2·4	+ 5·8	− 4·9	+ 0·9
31 10 38	+ 2·4	− 0·4	− 1·0	+ 1·0	+ 6·4	− 4·7	+ 1·7
Sept. 5 14 40	+ 4·7	− 0·5	− 4·6	− 0·4	+ 2·3	− 1·9	+ 0·4
8 17 20	+ 8·5	− 0·6	− 9·9	− 2·0	+ 1·6	+ 0·1	+ 1·7
9 18 17	+ 10·6	− 0·7	− 10·2	− 0·3	− 0·1	+ 1·7	+ 1·6

Approx. G.M.T. 1849.			Longitude.				E.N.P.D.		
d h m			B–O	Corr. to B.	H–B	H–O	B–O	H–B	H–O
			"	"	"	"	"	"	"
Sept. 22	4	31	+ 7·1	− 0·5	− 7·7	− 1·1	− 5·1	+ 0·1	− 5·0
25	6	53	− 0·9	− 0·2	+ 0·5	− 0·6	+ 4·0	− 3·5	+ 0·5
26	7	41	− 0·5	− 0·3	+ 1·2	+ 0·4	+ 5·4	− 4·4	+ 1·0
30	10	54	+ 2·6	− 0·5	− 2·4	− 0·3	+ 8·0	− 5·3	+ 2·7
Oct. 2	12	33	+ 10·2	− 0·8	− 7·2	+ 2·2	+ 7·1	− 3·5	+ 3·6
4	14	18	+ 10·4	− 0·8	− 8·5	+ 1·1	+ 4·9	− 0·8	+ 4·1
5	15	14	+ 8·4	− 0·7	− 8·3	− 0·6	+ 1·0	+ 0·6	+ 1·6
8	18	8	+ 7·1	− 0·6	− 10·0	− 3·5	+ 0·4	+ 4·9	+ 5·3
9	19	5	+ 11·2	− 0·8	− 10·6	− 0·2	− 6·3	+ 6·7	+ 0·4
28	9	31	+ 2·2	− 0·5	− 2·3	− 0·6	+ 9·1	− 7·9	+ 1·2
29	10	20	+ 4·3	− 0·6	− 4·9	− 1·2	+ 8·5	− 6·6	+ 1·9
31	12	6	+ 12·8	− 0·9	− 10·5	+ 1·4	+ 3·7	− 3·0	+ 0·7
Nov. 1	13	3	+ 9·6	− 0·7	− 11·5	− 2·6	+ 1·1	− 0·9	+ 0·2
4	16	2	+ 10·0	− 0·8	− 8·4	+ 0·8	− 4·0	+ 6·0	+ 2·0
5	17	1	+ 11·3	− 0·9	− 8·6	+ 1·8	− 5·9	+ 8·4	+ 2·5
22	5	48	+ 3·6	− 0·5	− 5·6	− 2·5	+ 9·8	− 4·9	+ 4·9
24	7	20	+ 6·2	− 0·7	− 8·4	− 2·9	+ 10·9	− 6·7	+ 4·2
25	8	8	+ 10·4	− 0·8	− 10·6	− 1·0	+ 10·4	− 6·9	+ 3·5
26	8	57	+ 9·4	− 0·8	− 11·8	− 3·2	+ 7·5	− 6·3	+ 1·2
27	9	49	+ 9·8	− 0·8	− 12·5	− 3·5	+ 9·3	− 4·8	+ 4·5
30	12	45	+ 11·1	− 0·8	− 12·0	− 1·7	− 1·0	+ 1·7	+ 0·7
Dec. 1	13	47	+ 13·3	− 1·0	− 9·9	+ 2·4	− 11·2	+ 3·8	− 7·4
4	16	45	+ 7·6	− 0·7	− 4·9	+ 2·0	− 11·6	+ 10·2	− 1·4
5	17	37	+ 6·5	− 0·7	− 6·4	− 0·6	− 9·9	+ 11·7	+ 1·8
6	18	27	+ 13·9	− 1·0	− 8·7	+ 4·2	− 12·7	+ 12·2	− 0·5
8	19	59	+ 7·7	− 0·7	− 8·4	− 1·4	− 10·8	+ 10·1	− 0·7
20	4	30	+ 5·2	− 0·5	− 7·0	− 2·3	+ 2·9	− 0·7	+ 2·2
21	5	15	+ 2·8	− 0·4	− 6·6	− 4·2	+ 1·1	− 0·9	+ 0·2
23	6	47	+ 10·3	− 0·7	− 11·8	− 2·2	+ 3·0	− 2·0	+ 1·0
27	10	22	+ 13·1	− 0·9	− 17·3	− 5·1	− 1·7	+ 1·8	+ 0·1
28	11	24	+ 12·9	− 0·9	− 16·3	− 4·3	− 0·2	+ 3·5	+ 3·3
29	12	28	+ 16·7	− 1·1	− 15·5	+ 0·1	− 2·8	+ 4·7	+ 1·9
31	14	31	+ 8·1	− 0·7	− 9·9	− 2·5	− 5·2	+ 6·8	+ 1 6

Approx. G.M.T. 1847.			Longitude.				E.N.P.D.		
d h m		B−O	Corr. to B.	H−B	H−O		B−O	H−B	H−O
Jan. 1 12 22		+ 2ʺ·8	− 0ʺ·4	− 1ʺ·9	+ 0ʺ·5		+ 0ʺ·2	+ 0ʺ·5	+ 0ʺ·7
5 15 25		− 0·2	− 0·4	+ 1·4	+ 0·8		− 4·9	+ 4·6	− 0·3
10 19 2		+ 6·8	− 0·6	− 4·5	+ 1·7		− 9·0	+ 7·1	− 1·9
23 5 59		+ 4·8	− 0·5	− 6·7	− 2·4		+ 4·3	− 5·4	− 1·1
24 6 51		+ 3·5	− 0·5	− 7·1	− 4·1		+ 2·9	− 5·4	− 2·5
28 10 17		− 2·1	− 0·2	+ 1·9	− 0·4		+ 0·1	+ 1·1	+ 1·2
29 11 5		− 2·2	− 0·2	+ 3·3	+ 0·9		− 1·6	+ 2·7	+ 1·1
31 12 38		− 0·3	− 0·3	+ 1·6	+ 1·0		− 3·7	+ 4·3	+ 0·6
Feb. 4 15 28		+ 4·4	− 0·5	− 0·2	+ 3·7		− 5·3	+ 4·4	− 0·9
6 16 56		+ 4·3	− 0·5	− 1·5	+ 2·3		− 7·9	+ 4·9	− 3·0
7 17 42		+ 5·1	− 0·5	− 2·7	+ 1·9		− 6·1	+ 5·3	− 0·8
8 18 31		+ 4·5	− 0·5	− 3·5	+ 0·5		− 4·4	+ 5·4	+ 1·0
19 3 52		+ 10·2	− 0·8	− 12·5	− 3·1		+ 2·7	− 5·3	− 2·6
24 8 14		+ 5·4	− 0·5	− 5·0	− 0·1		− 0·2	+ 2·6	+ 2·4
25 9 3		+ 3·2	− 0·4	− 1·6	+ 1·2		− 2·0	+ 4·8	+ 2·8
26 9 50		− 1·6	− 0·2	+ 1·5	− 0·3		− 4·6	+ 6·6	+ 2·0
28 11 19		− 2·6	− 0·2	+ 4·2	+ 1·4		− 5·3	+ 7·6	+ 2·3
Mar. 3 13 27		+ 6·2	− 0·5	− 3·0	+ 2·7		− 5·6	+ 6·6	+ 1·0
7 16 26		+ 6·6	− 0·6	− 3·8	+ 2·2		− 6·9	+ 5·8	− 1·1
9 18 8		+ 5·2	− 0·5	− 1·7	+ 3·0		− 5·6	+ 4·9	− 0·7
10 19 2		− 1·4	− 0·3	+ 0·5	− 1·2		− 8·6	+ 4·0	− 4·6
24 6 59		+ 5·1	− 0·5	− 7·5	− 2·9		− 1·0	+ 3·5	+ 2·5
25 7 47		+ 9·5	− 0·6	− 7·8	+ 1·1		− 2·2	+ 6·2	+ 4·0
26 8 33		+ 7·1	− 0·5	− 6·9	− 0·3		− 5·0	+ 8·0	+ 3·0
27 9 18		+ 5·7	− 0·5	− 4·9	+ 0·3		− 7·5	+ 9·4	+ 1·9
29 10 43		+ 4·5	− 0·5	− 0·2	+ 3·8		− 5·8	+ 9·4	+ 3·6
30 11 25		− 0·3	− 0·4	− 0·2	− 0·9		− 9·4	+ 9·0	− 0·4
Apr. 8 18 44		+ 6·4	− 0·6	− 1·7	+ 4·1		− 6·4	+ 2·4	− 4·0
22 6 29		+ 7·0	− 0·6	− 7·3	− 0·9		− 6·3	+ 5·0	− 1·3
23 7 14		+ 12·1	− 0·7	− 10·1	+ 1·3		− 5·8	+ 7·1	+ 1·3
24 7 58		+ 12·6	− 0·7	− 11·7	+ 0·2		− 7·1	+ 8·7	+ 1·6
25 8 41		+ 13·7	− 0·8	− 11·2	+ 1·7		− 9·2	+ 9·4	+ 0·2
27 10 5		+ 4·9	− 0·5	− 4·8	− 0·4		− 7·9	+ 9·0	+ 1·1
28 10 49		+ 1·1	− 0·4	− 2·0	− 1·3		− 6·0	+ 7·9	+ 1·9
29 11 34		+ 3·9	− 0·5	− 1·1	+ 2·3		− 5·7	+ 6·8	+ 1·1
30 12 20		+ 4·7	− 0·5	− 2·8	+ 1·4		− 5·1	+ 5·8	+ 0·7
May 4 15 46		+ 9·9	− 0·7	− 9·6	− 0·4		+ 2·7	+ 1·0	+ 3·7
6 17 33		+ 13·6	− 0·9	− 9·9	+ 2·8		+ 0·6	− 1·1	− 0·5

Errors of Hansen's Tables deduced

Approx. G.M.T. 1847.			Longitude.			E.N.P.D		
		B−O	Corr. to B.	H−B	H−O	B−O	H−B	H−O
d h m								
May 21	5 54	+ 6.3	−0.5	− 7.3	−1.5	− 3.5	+ 5.8	+ 2.3
22	6 37	+13.6	−0.8	− 9.8	+3.0	− 8.5	+ 7.7	− 0.8
25	8 44	+ 8.3	−0.6	− 7.9	−0.2	− 6.7	+10.0	+ 3.3
26	9 28	+ 6.4	−0.6	− 4.3	+1.5	− 8.9	+ 9.5	+ 0.6
27	10 15	+ 2.8	−0.5	− 1.7	+0.6	− 7.9	+ 8.4	+ 0.5
28	11 3	+ 1.9	−0.4	− 1.3	+0.2	− 7.0	+ 6.9	− 0.1
29	11 54	+ 2.5	−0.4	− 2.1	0.0	− 2.4	+ 4.9	+ 2.5
30	12 47	+ 7.1	−0.6	− 4.0	+2.5	− 2.9	+ 3.0	+ 0.1
31	13 41	+ 3.7	−0.4	− 5.7	−2.4	− 1.1	+ 1.3	+ 0.2
June 1	14 36	+ 7.0	−0.6	− 7.4	−1.0	+ 2.0	− 0.3	+ 1.7
2	15 30	+10.7	−0.8	− 9.1	+0.8	+ 4.6	− 1.6	+ 3.0
6	19 0	+ 9.3	−0.8	− 5.5	+3.0	+ 8.6	− 8.0	+ 0.6
19	5 15	+ 5.4	−0.5	− 7.0	−2.1	− 4.2	+ 5.6	+ 1.4
22	7 22	+ 5.8	−0.6	− 5.6	−0.4	− 7.4	+ 9.1	+ 1.7
23	8 7	+ 1.9	−0.4	− 4.2	−2.7	− 7.5	+ 9.8	+ 2.3
27	11 31	+ 5.2	−0.5	− 7.1	−2.4	− 7.0	+ 6.7	− 0.3
July 4	17 49	+ 9.4	−0.8	− 6.7	+1.9	+ 4.9	− 5.9	− 1.0
5	18 41	+ 6.8	−0.7	− 3.8	+2.3	+ 6.9	− 7.0	− 0.1
21	6 46	+ 3.3	−0.4	− 5.0	−2.1	− 3.5	+ 7.2	+ 3.7
22	7 34	+ 4.5	−0.5	− 6.1	−2.1	− 8.5	+ 7.8	− 0.7
23	8 24	+ 7.5	−0.6	− 7.4	−0.5	− 4.0	+ 8.1	+ 4.1
25	10 13	+14.7	−0.9	−10.6	+3.2	− 5.6	+ 7.6	+ 2.0
26	11 9	+12.0	−0.8	−12.7	−1.5	− 3.4	+ 6.3	+ 2.9
27	12 6	+14.1	−0.9	−14.0	−0.8	+ 2.5	+ 5.1	+ 7.6
29	13 58	+17.4	−0.9	−13.9	+2.6	− 7.0	+ 1.8	− 5.2
30	14 52	(+ 9.0)	−1.0	−11.5	(−3.5)	(+14.7)	− 0.1	(+14.6)
31	15 45	+12.6	−0.9	− 8.2	+3.5	+ 1.4	− 1.5	− 0.1
Aug. 1	16 38	+ 5.0	−0.6	− 5.2	−0.8	+ 3.9	− 3.1	+ 0.8
2	17 31	(+ 4.5)	−0.7	− 4.1	(−0.3)	(+15.7)	− 3.9	(+11.8)
3	18 25	+ 5.4	−0.6	− 4.4	+0.4	+ 4.6	− 3.8	+ 0.8
20	7 5	+ 7.7	−0.6	−10.7	−3.6	− 2.3	+ 3.2	+ 0.9
21	7 58	+ 9.1	−0.7	−11.8	−3.4	− 1.7	+ 3.2	+ 1.5
23	9 49	+10.0	−0.7	−11.7	−2.4	− 1.9	+ 3.0	+ 1.1
26	12 39	+17.3	−1.1	−14.0	+2.2	+ 4.4	+ 0.3	+ 4.7
27	13 34	+16.5	−1.1	−12.8	+2.6	+ 3.6	− 1.1	+ 2.5

Approx. G.M.T. 1847.			B−O	Longitude. Corr. to B.	H−B	H−O	E.N.P.D. B−O	H−B	H−O
d	h	m							
Aug. 29	15	24	+ 10ʺ4	− 0ʺ9	− 7ʺ2	+ 2ʺ3	+ 8ʺ0	− 3ʺ4	+ 4ʺ6
31	17	14	+ 8·9	− 0·8	− 6·6	+ 1·5	+ 5·3	− 3·0	+ 2·3
Sept. 1	18	9	+ 8·2	− 0·7	− 7·3	+ 0·2	+ 2·6	− 1·7	+ 0·9
3	19	55	+ 10·8	− 0·7	− 5·8	+ 4·3	− 2·0	+ 2·3	+ 0·3
18	6	41	+ 15·7	− 1·0	− 11·5	+ 3·2	+ 3·5	− 0·8	+ 2·7
22	10	21	+ 5·2	− 0·6	− 5·8	− 1·2	+ 0·9	− 2·2	− 1·3
23	11	17	+ 4·8	− 0·6	− 6·3	− 2·1	+ 2·9	− 3·0	− 0·1
24	12	13	+ 10·8	− 0·9	− 7·7	+ 2·2	+ 5·3	− 4·1	+ 1·2
26	14	7	+ 10·5	− 1·0	− 9·4	+ 0·1	+ 11·5	− 5·1	+ 6·4
27	15	4	+ 15·7	− 1·1	− 9·9	+ 4·7	+ 4·9	− 4·4	+ 0·5
28	16	1	+ 13·6	− 1·0	− 10·3	+ 2·3	+ 5·1	− 3·1	+ 2·0
Oct. 18	7	12	+ 5·5	− 0·6	− 7·1	− 2·2	+ 2·0	− 1·8	+ 0·2
19	8	6	+ 2·4	− 0·5	− 5·7	− 3·8	+ 1·6	− 2·2	− 0·6
20	9	0	+ 2·9	− 0·5	− 3·4	− 1·0	+ 2·1	− 2·9	− 0·8
21	9	54	+ 0·3	− 0·5	− 1·2	− 1·4	+ 5·4	− 3·5	+ 1·9
22	10	50	− 0·3	− 0·4	− 1·2	− 1·9	+ 4·5	− 4·5	0·0
24	12	46	+ 9·8	− 0·9	− 6·8	+ 2·1	+ 5·0	− 5·1	− 0·1
25	13	44	+ 14·4	− 1·0	− 9·1	+ 4·3	+ 2·8	− 3·9	− 1·1
26	14	43	+ 15·9	− 1·1	− 9·9	+ 4·9	+ 1·9	− 2·3	− 0·4
29	17	25	+ 14·2	− 0·9	− 7·5	+ 5·8	− 3·7	+ 3·6	− 0·1
30	18	14	+ 7·9	− 0·6	− 6·7	+ 0·6	− 4·9	+ 5·1	+ 0·2
Nov. 1	19	44	+ 6·2	− 0·6	− 5·2	+ 0·4	− 11·8	+ 7·1	− 4·7
18	8	35	+ 5·2	− 0·6	− 5·6	− 1·0	+ 4·3	− 2·9	+ 1·4
19	9	30	+ 2·5	− 0·5	− 3·7	− 1·7	+ 3·8	− 3·6	+ 0·2
23	13	22	+ 9·9	− 0·8	− 6·9	+ 2·2	− 0·4	− 1·5	− 1·9
24	14	20	+ 13·1	− 0·9	− 7·4	+ 4·8	− 0·8	− 0·1	− 0·9
27	16	54	+ 6·0	− 0·6	− 4·4	+ 1·0	− 3·8	+ 4·7	+ 0·9
28	17	40	+ 9·1	− 0·7	− 4·3	+ 4·1	− 6·6	+ 6·0	− 0·6
30	19	6	+ 7·3	− 0·7	− 4·8	+ 1·8	− 11·9	+ 8·1	− 3·8
Dec. 1	19	48	+ 7·7	− 0·7	− 4·5	+ 2·5	− 11·3	+ 8·7	− 2·6
13	4	47	+ 7·2	− 0·5	− 7·7	− 1·0	− 1·0	+ 1·2	+ 0·2
14	5	38	+ 5·6	− 0·5	− 7·4	− 2·3	+ 1·7	+ 0·4	+ 2·1
16	7	21	+ 8·5	− 0·7	− 9·0	− 1·2	+ 4·0	− 2·3	+ 1·7
19	10	7	+ 4·6	− 0·5	− 8·3	− 4·2	− 1·4	− 3·0	− 4·4
28	17	44	+ 3·6	− 0·5	− 2·7	+ 0·4	− 4·5	+ 5·8	+ 1·3
31	19	53	+ 3·2	− 0·5	− 3·0	− 0·3	− 5·8	+ 6·6	+ 0·8

Approx. G.M.T. 1848.			Longitude.				E.N.P.D.		
			B−O	Corr. to B.	H−B	H−O	B−O	H−B	H−O
Jan. d 12	h 5	m 19	+6″·1	−0″·6	− 8″·8	− 3″·3	+ 3″·3	− 2″·4	+0″·9
15	7	59	+8·5	−0·7	−11·8	−4·0	+4·5	−3·0	+1·5
16	8	55	+7·4	−0·6	−11·9	−5·1	+0·8	−1·7	−0·9
26	17	4	+2·4	−0·4	− 1·8	+0·2	−5·2	+4·3	−0·9
Feb. 12	6	50	+4·7	−0·5	−11·9	−7·7	+1·5	−2·6	−1·1
14	8	40	+8·3	−0·6	−11·5	−3·8	+1·1	+2·0	+3·1
15	9	34	+7·2	−0·6	− 8·2	−1·6	−2·7	+3·7	+1·0
16	10	26	+3·4	−0·4	− 5·0	−2·0	−2·8	+5·0	+2·2
17	11	16	+2·6	−0·4	− 3·1	−0·9	−3·7	+5·4	+1·7
18	12	3	+1·8	−0·4	− 3·3	−1·9	−4·4	+5·6	+1·2
20	13	33	+2·2	−0·4	− 4·9	−3·1	−5·9	+5·2	−0·7
22	14	59	+3·4	−0·5	− 2·9	0·0	−5·9	+4·2	−1·7
27	18	47	+0·8	−0·4	− 1·1	−0·7	−2·7	+2·9	+0·2
28	19	37	−0·3	−0·3	+ 0·9	+0·3	+1·8	+2·8	+4·6
Mar. 11	5	41	+7·7	−0·7	− 9·8	−2·8	+2·6	−1·2	+1·4
14	8	22	+4·7	−0·5	− 8·6	−4·4	−4·6	+5·2	+0·6
18	11	30	+3·8	−0·5	− 3·3	0·0	−6·8	+7·6	+0·8
19	12	13	+5·5	−0·6	− 4·0	+0·9	−9·3	+6·9	−2·4
21	13	39	+7·6	−0·6	− 5·3	+1·7	−5·4	+4·9	−0·5
Apr. 10	6	19	−0·6	−0·3	− 3·7	−4·6	−0·9	+3·0	+2·1
14	9	28	+6·2	−0·6	− 6·6	−1·0	−7·0	+8·5	+1·5
17	11	37	+1·8	−0·4	− 3·5	−2·1	−5·4	+6·1	+0·7
18	12	20	+6·3	−0·6	− 4·4	+1·3	−6·0	+4·7	−1·3
19	13	4	+4·1	−0·5	− 5·7	−2·1	−2·5	+2·9	+0·4
25	17	55	+7·7	−0·7	− 4·9	+2·1	+3·9	−1·6	+2·3
May 7	4	9	−1·4	−0·3	− 1·2	−2·9	−0·9	−0·6	−1·5
8	5	3	−0·2	−0·3	− 0·4	−0·9	+0·4	+1·3	+1·7
9	5	54	−1·2	−0·3	− 2·0	−3·5	−4·5	+3·3	−1·2
10	6	41	+3·2	−0·5	− 5·1	−2·4	−3·5	+5·4	+1·9
11	7	27	+7·3	−0·6	− 7·8	−1·1	−7·1	+7·1	0·0
12	8	10	+9·3	−0·7	− 9·1	−0·5	−6·4	+8·1	+1·7
13	8	53	+7·7	−0·6	− 8·5	−1·4	−6·1	+8·4	+2·3
14	9	35	+5·6	−0·5	− 6·3	−1·2	−6·0	+7·8	+1·8
15	10	18	+5·3	−0·5	− 3·8	+1·0	−3·5	+6·4	+2·9
16	11	2	+2·2	−0·4	− 2·1	−0·3	−0·9	+4·8	+3·9
18	12	34	+3·6	−0·4	− 2·7	+0·5	+2·5	+1·0	+3·5
20	14	11	+7·8	−0·6	− 6·1	+1·1	+3·1	−1·8	+1·3

Approx. G.M.T. 1848.			Longitude				E.N.P.D.		
			B−O	Corr. to B.	H−B	H−O	B−O	H−B	H−O
d	h	m							
May 22	15	52	+ 9˙3	−0˙7	− 8˙8	−0˙2	+5˙0	− 3˙6	+1˙4
23	16	42	+ 12˙3	−0˙8	− 9˙7	+1˙8	+4˙3	− 4˙2	+0˙1
24	17	32	+ 15˙2	−1˙0	−10˙0	+4˙2	+7˙1	− 5˙2	+1˙9
June 5	3	45	+ 7˙5	−0˙6	− 6˙6	+0˙3	+3˙4	− 0˙7	+2˙7
6	4	35	+ 4˙2	−0˙5	− 6˙4	−2˙7	−0˙1	+ 1˙1	+1˙0
7	5	22	− 0˙4	−0˙3	− 6˙5	−7˙2	−3˙5	+ 3˙0	−0˙5
11	8	16	+ 7˙1	−0˙5	− 8˙8	−2˙2	−4˙1	+ 7˙0	+2˙9
13	9	44	+ 4˙5	−0˙4	− 4˙4	−0˙3	−0˙6	+ 4˙7	+4˙1
15	11	18	− 0˙1	−0˙3	− 1˙0	−1˙4	+1˙1	+ 2˙0	+3˙1
21	16	20	+13˙7	−0˙9	−11˙3	+1˙5	+5˙7	− 4˙1	+1˙6
July 5	4	1	+ 9˙1	−0˙6	−12˙1	−3˙6	+1˙2	+ 2˙6	+3˙8
6	4	46	+ 8˙3	−0˙6	− 9˙1	−1˙4	−1˙9	+ 3˙1	+1˙2
11	8	25	+ 4˙0	−0˙4	− 6˙1	−2˙5	−1˙4	+ 2˙5	+1˙1
12	9	12	+ 6˙0	−0˙5	− 5˙1	+0˙4	−0˙1	+ 1˙9	+1˙8
13	10	1	− 0˙3	−0˙3	− 4˙8	−5˙4	+0˙6	+ 1˙4	+2˙0
15	11	43	+ 4˙6	−0˙5	− 6˙4	−2˙3	+0˙6	+ 1˙0	+1˙6
16	12	34	+11˙5	−0˙7	− 7˙9	+2˙9	−2˙5	+ 1˙0	−1˙5
17	13	26	+11˙2	−0˙8	− 8˙6	+1˙8	+4˙2	+ 0˙4	+4˙6
18	14	17	+13˙9	−0˙9	− 8˙8	+4˙2	+2˙5	− 0˙4	+2˙1
20	15	58	+ 7˙4	−0˙6	− 9˙3	−2˙5	−1˙5	− 2˙8	−4˙3
21	16	49	+12˙9	−0˙9	−10˙2	+1˙8	+5˙3	− 3˙7	+1˙6
Aug. 4	4	7	+ 3˙8	−0˙4	− 8˙6	−5˙2	−2˙3	+ 3˙1	+0˙8
5	4	50	+ 2˙6	−0˙4	− 4˙9	−2˙7	−1˙4	+ 2˙0	+0˙6
10	8	42	+ 2˙4	−0˙4	− 5˙2	−3˙2	+0˙5	− 0˙8	−0˙3
16	13	53	+12˙2	−0˙9	− 8˙6	+2˙7	+3˙2	− 0˙8	+2˙4
17	14	45	+13˙2	−0˙9	− 7˙7	+4˙6	−0˙3	− 1˙6	−1˙9
18	15	38	+10˙6	−0˙8	− 7˙5	+2˙3	−0˙4	− 2˙1	−2˙5
19	16	31	+12˙3	−0˙9	− 8˙4	+3˙0	+0˙9	− 2˙4	−1˙5
22	19	18	+12˙5	−0˙8	−10˙6	+1˙1	+0˙4	+ 2˙1	+2˙5
Sept. 4	4	58	+ 0˙4	−0˙3	− 3˙0	−2˙9	+1˙3	− 1˙1	+0˙2
6	6	32	− 1˙9	−0˙2	− 2˙2	−4˙3	+5˙4	− 2˙4	+3˙0
8	8	13	− 1˙5	−0˙3	− 3˙3	−5˙1	+9˙2	− 2˙7	+6˙5
11	10	49	+ 3˙9	−0˙5	− 5˙3	−1˙9	+2˙2	− 2˙2	0˙0
12	11	42	+ 8˙5	−0˙7	− 6˙4	+1˙4	+5˙3	− 2˙2	+3˙1
14	13	29	+12˙0	−0˙9	− 9˙0	+2˙1	+4˙1	− 2˙4	+1˙7
15	14	24	+15˙7	−1˙1	− 9˙9	+4˙7	+4˙1	− 2˙2	+1˙9
16	15	20	+15˙4	−1˙0	−10˙3	+4˙1	+2˙2	− 1˙7	+0˙5
17	16	16	+14˙4	−1˙0	−10˙5	+2˙9	+1˙1	− 1˙1	0˙0
18	17	14	+14˙0	−1˙0	−10˙9	+2˙1	−0˙4	+ 0˙5	+0˙1
19	18	11	+17˙1	−1˙1	−11˙2	+4˙8	−2˙1	+ 2˙0	−0˙1
20	19	6	+19˙1	−1˙1	−11˙0	+7˙0	−8˙1	+ 3˙7	−4˙4

Errors of Hansen's Tables deduced

Approx. G.M.T. 1848.			B–O	Longitude.			R.N.P.D.		
				Corr. to B.	H–B	H–O	B–O	H–B	H–O
	d	h	m							
Oct.	3	4	26	+ 3·3	−0·4	− 6·7	−3·8	− 5·3	− 3·5	−8·8
	5	6	3	+ 4·3	−0·5	− 3·8	0·0	+ 8·3	− 4·2	+4·1
	6	6	53	+ 7·0	−0·6	− 3·6	+2·8	+ 3·5	− 4·3	−0·8
	8	8	34	+ 1·9	−0·5	− 2·1	−0·7	+ 6·5	− 4·5	+2·0
	9	9	26	+ 0·1	−0·4	− 0·8	−1·1	+ 5·3	− 4·5	+0·8
	10	10	19	+ 1·9	−0·5	− 0·4	+1·0	+ 2·8	− 4·2	−1·4
	11	11	13	+ 4·7	−0·6	− 2·1	+2·0	+ 3·8	− 4·1	−0·3
	12	12	9	+12·0	−0·9	− 5·7	+5·4	+ 5·4	− 3·7	+1·7
	14	14	5	+10·7	−0·9	−10·9	−1·1	+ 6·6	− 1·2	+5·4
	18	17	56	+15·1	−0·9	−10·6	+3·6	− 4·4	+ 5·8	+1·4
Nov.	4	6	24	+ 8·7	−0·6	− 8·6	−0·5	− 1·1	− 4·3	−5·4
	5	7	14	+ 9·9	−0·7	− 9·0	+0·2	+ 4·7	− 5·0	−0·3
	7	8	56	+ 4·8	−0·7	− 6·7	−2·6	+ 8·2	− 5·5	+2·7
	9	10	46	+ 6·9	−0·7	− 6·1	+0·1	+ 3·5	− 3·8	−0·3
	10	11	45	+ 4·3	−0·6	− 7·5	−3·8	− 0·1	− 2·4	−2·5
	12	13	47	+ 8·8	−0·8	− 7·9	+0·1	− 2·4	+ 0·9	−1·5
	14	15	47	+10·0	−0·8	− 4·9	+4·3	− 4·9	+ 4·8	−0·1
	15	16	42	+ 6·9	−0·7	− 4·9	+1·3	− 7·1	+ 6·6	−0·5
	17	18	23	+11·6	−0·9	− 6·0	+4·7	−10·4	+10·0	−0·4
	18	19	10	+ 7·8	−0·8	− 5·3	+1·7	−13·4	+10·9	−2·5
	20	20	37	+ 7·3	−0·6	− 3·3	+3·4	− 7·4	+ 9·9	+2·5
Dec.	1	4	20	+ 6·6	−0·5	−12·4	−6·3	− 0·2	− 0·6	−0·8
	2	5	9	+ 6·8	−0·5	−10·8	−4·5	− 0·5	− 0·7	−1·2
	3	5	57	+10·5	−0·7	−11·2	−1·4	+ 1·0	− 1·7	−0·7
	4	6	46	+12·3	−0·8	−13·3	−1·8	+ 2·8	− 2·5	+0·3
	5	7	37	+11·8	−0·8	−15·3	−4·3	+ 1·1	− 3·3	−2·2
	6	8	30	+12·2	−0·9	−15·9	−4·6	+ 2·8	− 3·1	−0·3
	9	11	24	+ 7·6	−0·7	−11·3	−4·4	− 1·1	+ 0·6	−0·5
	10	12	27	+ 9·6	−0·8	− 9·7	−0·9	− 2·4	+ 1·5	−0·9
	11	13	28	+ 6·1	−0·6	− 7·7	−2·2	− 2·0	+ 2·7	+0·7
	12	14	28	+ 4·5	−0·6	− 4·6	−0·7	− 4·9	+ 3·0	−1·9
	13	15	24	+ 1·8	−0·5	− 2·4	−1·1	− 8·0	+ 4·7	−3·3
	17	18	35	+ 5·9	−0·6	− 3·5	+1·8	− 9·0	+ 7·7	−1·3
	20	20	45	+ 6·3	−0·5	− 3·7	+2·1	− 2·4	+ 4·6	+2·2
	21	21	30	+ 7·1	−0·6	− 3·2	+3·3	− 5·4	+ 3·0	−2·4

Approx. G.M.T. 1849.			Longitude.			E.N.P.D.		
		B—O	Corr. to B.	H—B	H—O	B—O	H—B	H—O
d h m		"	"	"	"	"	"	"
Jan. 2 6 22		+ 5·6	−0·5	−10·2	− 5·1	+ 0·9	+0·2	+1·1
6 10 6		+ 7·4	−0·7	−14·5	− 7·8	− 2·0	+2·4	+0·4
8 12 8		+10·5	−0·8	−12·7	− 3·0	− 2·7	+4·3	+1·6
10 14 2		+12·7	−0·8	−11·0	+ 0·9	− 3·1	+4·6	+1·5
14 17 14		+ 6·2	−0·5	− 5·3	+ 0·4	− 3·4	+3·8	+0·4
15 17 58		+ 8·8	−0·6	− 5·6	+ 2·6	− 4·0	+3·0	−1·0
17 19 26		+ 9·0	−0·6	− 5·5	+ 2·9	− 1·6	+0·8	−0·8
28 3 30		+ 2·8	−0·3	− 7·9	− 5·4	− 4·6	0·0	−4·6
31 6 3		+ 1·0	−0·3	− 7·5	− 6·8	− 1·3	+0·2	−1·1
Feb. 4 9 52		+ 8·4	−0·7	−14·0	− 6·3	− 4·0	+5·7	+1·7
8 13 31		+11·4	−0·8	−12·4	− 1·8	− 7·9	+6·4	−1·5
10 15 6		+13·3	−0·8	−10·3	+ 2·2	− 5·7	+4·5	−1·2
11 15 51		+10·1	−0·6	− 9·0	+ 0·5	− 3·3	+3·3	0·0
12 16 35		+ 6·6	−0·5	− 8·1	− 2·0	− 1·1	+1·9	+0·8
13 17 20		+ 7·1	−0·5	− 7·7	− 1·1	− 0·3	+0·6	+0·3
16 19 38		(+ 3·3)	−0·4	− 3·3	− 0·4	(+11·6)	−2·1	(+9·5)
17 20 26		(+ 1·8)	−0·3	− 0·2	+ 1·3	(− 1·1)	−2·0	(−3·1)
27 3 59		+ 6·2	−0·6	− 9·5	− 3·7	+ 3·8	−1·0	+2·8
Mar. 1 5 49		+ 2·8	−0·4	− 9·2	− 6·8	− 0·2	+0·2	0·0
2 6 46		+ 1·3	−0·4	−11·2	−10·3	− 3·2	+1·8	−1·4
4 8 41		+11·6	−0·8	−15·8	− 5·0	− 5·3	+6·1	+0·8
5 9 37		+ 9·7	−0·7	−15·5	− 6·5	− 6·4	+7·8	+1·4
8 12 10		+ 8·5	−0·7	− 7·7	+ 0·1	− 5·2	+8·0	+2·8
9 12 57		+ 6·4	−0·6	− 7·0	− 1·2	− 5·2	+6·6	+1·4
10 13 43		+ 8·1	−0·7	− 7·1	+ 0·3	− 8·1	+5·0	−3·1
16 18 18		+ 6·3	−0·5	− 4·9	+ 0·9	+ 1·2	−2·4	−1·2
31 6 37		+ 3·1	−0·5	− 9·6	− 7·0	− 7·2	+4·3	−2·9
Apr. 1 7 32		+11·0	−0·7	−12·6	− 2·3	− 3·0	+6·1	+3·1
2 8 25		+12·0	−0·8	−14·1	− 2·9	− 5·7	+7·7	+2·0
5 10 52		+ 2·2	−0·5	− 6·4	− 4·7	− 7·3	+8·0	+0·7
6 11 37		+ 1·1	−0·4	− 4·4	− 3·7	− 8·1	+6·5	−1·6
7 12 22		+ 5·2	−0·5	− 3·9	+ 0·8	− 5·6	+4·6	−1·0
8 13 7		+ 8·9	−0·6	− 4·3	+ 4·0	− 0·8	+2·3	+1·5
11 15 24		+ 4·0	−0·4	− 2·9	+ 0·7	+ 4·2	−2·9	+1·3
13 16 59		+ 4·2	−0·5	− 3·4	+ 0·3	+ 7·4	−3·9	+3·5
15 18 35		+ 8·4	−0·6	− 2·4	+ 5·4	+ 3·2	−4·0	−0·8
16 19 23		+ 4·4	−0·5	+ 1·1	+ 5·0	+ 5·5	−3·7	+1·8
27 4 30		+ 3·6	−0·6	− 5·4	− 2·4	−11·0	+4·0	−7·0
28 5 28		+ 1·5	−0·5	− 4·1	− 3·1	− 6·1	+5·0	−1·1

Approx. G.M.T. 1849.			Longitude.				E.N.P.D.		
			B−O	Corr. to B.	H−B	H−O	B−O	H−B	H−O
d	h	m							
May 3	9	35	+ 3·3	−0·5	− 6·0	−3·2	− 7·9	+7·9	0·0
4	10	20	+ 3·3	−0·4	− 4·8	−1·9	− 4·5	+6·0	+1·5
5	11	4	+ 3·6	−0·4	− 4·3	−1·1	− 4·4	+3·8	−0·6
7	12	34	+ 4·1	−0·4	− 4·7	−1·0	− 0·3	−0·4	−0·7
26	4	15	+ 4·9	−0·5	− 8·5	−4·1	− 2·5	+3·6	+1·1
27	5	9	− 1·1	−0·3	− 5·3	−6·7	− 2·7	+4·8	+2·1
29	6	48	− 0·7	−9·4	− 3·9	−5·0	− 7·8	+7·1	−0·7
31	8	19	+ 2·9	−0·4	− 5·5	−3·0	− 6·3	+6·5	+0·2
June 1	9	3	+ 3·1	−0·4	− 5·5	−2·8	− 4·5	+4·6	+0·1
2	9	47	+ 4·3	−0·5	− 5·0	−1·2	− 1·9	+2·9	+1·0
3	10	32	+ 5·1	−0·4	− 4·0	+0·7	− 3·1	+1·1	−2·0
11	16	48	+ 7·2	−0·6	− 6·4	+0·2	+ 7·7	−6·7	+1·0
13	18	22	+ 4·0	−0·6	− 6·3	−2·9	+15·9	−8·5	+7·4
24	3	52	+ 9·3	−0·7	−14·5	−5·9	− 5·8	+4·2	−1·6
27	6	17	+ 3·2	−0·4	− 5·8	−3·0	− 0·7	+3·9	+3·2
July 4	11	36	+ 1·2	−0·3	− 0·2	+0·7	+ 5·0	−3·4	+1·6
5	12	24	+ 3·0	−0·4	− 0·9	+1·7	+ 5·1	−3·3	+1·8
6	13	12	+ 6·0	−0·5	− 3·0	+2·5	+ 4·1	−3·2	+0·9
7	13	59	+ 8·8	−0·6	− 5·1	+3·1	+ 4·6	−3·1	+1·5
8	14	46	+13·4	−0·8	− 6·0	+6·6	+ 6·9	−3·4	+3·5
9	15	33	+ 6·3	−0·5	− 7·2	−1·4	+ 3·5	−3·8	−0·3
10	16	20	+ 9·8	−0·7	− 8·4	+0·7	+ 6·4	−4·2	+2·2
11	17	7	+12·3	−0·7	−10·0	+1·6	+ 4·3	−4·9	−0·6
24	4	10	+ 8·7	−0·7	−13·5	−5·5	− 3·5	+5·9	+2·4
28	7	11	+ 7·4	−0·4	− 5·7	+1·3	+ 3·2	−1·8	+1·4
29	7	57	+ 5·8	−0·4	− 4·9	+0·5	+ 5·3	−3·6	+1·7
30	8	44	+ 5·3	−0·4	− 3·5	+1·4	+ 7·5	−4·8	+2·7
31	9	31	+ 1·2	−0·3	− 1·8	−0·9	+ 6·4	−5·1	+1·3
Aug. 1	10	19	+ 3·2	−0·4	− 0·7	+2·1	+ 6·7	−5·0	+1·7
3	11	56	+ 2·0	−0·4	− 1·3	+0·3	+ 5·8	−3·7	+2·1
4	12	44	+ 6·2	−0·6	− 2·8	+2·8	+ 6·3	−3·2	+3·1
6	14	18	+ 7·0	−0·6	− 4·5	+1·9	+ 4·0	−2·6	+1·4
8	15	53	+10·4	−0·7	− 7·7	+2·0	+ 2·7	−2·4	+0·3
11	18	28	+12·6	−0·8	−12·0	−0·2	+ 1·1	+0·4	+1·5
24	5	6	+ 8·5	−0·5	− 7·5	+0·5	+ 0·7	+1·8	+2·5
29	9	1	+ 3·4	−0·4	− 0·6	+2·4	+ 5·8	−4·9	+0·9
31	10	38	+ 2·4	−0·4	− 1·0	+1·0	+ 6·4	−4·7	+1·7
Sept. 5	14	40	+ 4·7	−0·5	− 4·6	−0·4	+ 2·3	−1·9	+0·4
8	17	20	+ 8·5	−0·6	− 9·9	−2·0	+ 1·6	+0·1	+1·7
9	18	17	+10·6	−0·7	−10·2	−0·3	− 0·1	+1·7	+1·6

Approx. G.M.T. 1849.			Longitude.				E.N.P.D.		
			B−O	Corr. to B.	H−B	H−O	B−O	H−B	H−O
d	h	m	"	"	"	"	"	"	"
Sept. 22	4	31	+ 7·1	−0·5	− 7·7	− 1·1	− 5·1	+ 0·1	−5·0
25	6	53	− 0·9	−0·2	+ 0·5	−0·6	+ 4·0	− 3·5	+0·5
26	7	41	− 0·5	−0·3	+ 1·2	+0·4	+ 5·4	− 4·4	+1·0
30	10	54	+ 2·6	−0·5	− 2·4	−0·3	+ 8·0	− 5·3	+2·7
Oct. 2	12	33	+10·2	−0·8	− 7·2	+2·2	+ 7·1	− 3·5	+3·6
4	14	18	+10·4	−0·8	− 8·5	+1·1	+ 4·9	− 0·8	+4·1
5	15	14	+ 8·4	−0·7	− 8·3	−0·6	+ 1·0	+ 0·6	+1·6
8	18	8	+ 7·1	−0·6	−10·0	−3·5	+ 0·4	+ 4·9	+5·3
9	19	5	+11·2	−0·8	−10·6	−0·2	− 6·3	+ 6·7	+0·4
28	9	31	+ 2·2	−0·5	− 2·3	−0·6	+ 9·1	− 7·9	+1·2
29	10	20	+ 4·3	−0·6	− 4·9	−1·2	+ 8·5	− 6·6	+1·9
31	12	6	+12·8	−0·9	−10·5	+1·4	+ 3·7	− 3·0	+0·7
Nov. 1	13	3	+ 9·6	−0·7	−11·5	−2·6	+ 1·1	− 0·9	+0·2
4	16	2	+10·0	−0·8	− 8·4	+0·8	− 4·0	+ 6·0	+2·0
5	17	1	+11·3	−0·9	− 8·6	+1·8	− 5·9	+ 8·4	+2·5
22	5	48	+ 3·6	−0·5	− 5·6	−2·5	+ 9·8	− 4·9	+4·9
24	7	20	+ 6·2	−0·7	− 8·4	−2·9	+10·9	− 6·7	+4·2
25	8	8	+10·4	−0·8	−10·6	−1·0	+10·4	− 6·9	+3·5
26	8	57	+ 9·4	−0·8	−11·8	−3·2	+ 7·5	− 6·3	+1·2
27	9	49	+ 9·8	−0·8	−12·5	−3·5	+ 9·3	− 4·8	+4·5
30	12	45	+11·1	−0·8	−12·0	−1·7	− 1·0	+ 1·7	+0·7
Dec. 1	13	47	+13·3	−1·0	− 9·9	+2·4	−11·2	+ 3·8	−7·4
4	16	45	+ 7·6	−0·7	− 4·9	+2·0	−11·6	+10·2	−1·4
5	17	37	+ 6·5	−0·7	− 6·4	−0·6	− 9·9	+11·7	+1·8
6	18	27	+13·9	−1·0	− 8·7	+4·2	−12·7	+12·2	−0·5
8	19	59	+ 7·7	−0·7	− 8·4	−1·4	−10·8	+10·1	−0·7
20	4	30	+ 5·2	−0·5	− 7·0	−2·3	+ 2·9	− 0·7	+2·2
21	5	15	+ 2·8	−0·4	− 6·6	−4·2	+ 1·1	− 0·9	+0·2
23	6	47	+10·3	−0·7	−11·8	−2·2	+ 3·0	− 2·0	+1·0
27	10	22	+13·1	−0·9	−17·3	−5·1	− 1·7	+ 1·8	+0·1
28	11	24	+12·9	−0·9	−16·3	−4·3	− 0·2	+ 3·5	+3·3
29	12	28	+16·7	−1·1	−15·5	+0·1	− 2·8	+ 4·7	+1·9
31	14	31	+ 8·1	−0·7	− 9·9	−2·5	− 5·2	+ 6·8	+1·6

Approx. G.M.T. 1850			Longitude.				E.N.P.D.		
		B−O	Corr. to B.	H−B	H−O		B−O	H−B	H−O
	d h m								
Jan. 1 15 28		+ 7″8	−0″7	− 6″6	+0″5		− 7″7	+ 7″4	−0″3
4 17 57		+ 9·0	−0·7	− 7·7	+0·6		− 6·8	+ 6·1	−0·7
5 18 43		+ 8·3	−0·7	− 7·8	−0·2		− 7·3	+ 4·4	−2·9
6 19 28		+ 6·8	−0·5	− 6·5	−0·2		− 3·8	+ 2·1	−1·7
23 8 5		+ 4·6	−0·5	−13·9	−9·8		− 2·1	+ 2·4	+0·3
26 11 8		+14·0	−1·0	−18·5	−5·5		− 6·7	+ 6·7	0·0
30 14 59		+10·4	−0·8	−13·0	−3·4		− 5·4	+ 6·7	+1·3
Feb. 1 16 37		+ 7·7	−0·6	− 8·7	−1·6		− 4·3	+ 2·9	−1·4
3 18 10		+11·0	−0·6	− 7·4	+3·0		+ 3·1	− 1·4	+1·7
5 19 43		+ 4·2	−0·4	− 2·7	+1·1		+ 7·0	− 4·8	+2·2
16 3 28		− 2·0	−0·2	− 2·1	−4·3		− 3·5	− 0·9	−4·4
18 5 5		− 6·1	−0·1	− 1·1	−7·3		+ 0·8	− 0·4	+0·4
21 7 50		+ 2·6	−0·4	−11·8	−9·6		− 3·3	+ 3·0	−0·3
22 8 50		+ 8·5	−0·7	−14·8	−7·0		− 3·6	+ 5·0	+1·4
23 9 51		+ 9·8	−0·7	−16·3	−7·2		− 6·6	+ 7·2	+0·6
26 12 43		+12·5	−1·0	−14·9	−3·4		−12·3	+ 9·7	−2·6
Mar. 3 16 49		+ 8·9	−0·6	− 8·0	+0·3		+ 0·1	− 0·2	−0·1
4 17 36		+ 8·2	−0·6	− 7·1	+0·5		+ 1·8	− 2·1	−0·3
5 18 24		+ 6·0	−0·5	− 6·2	−0·7		+ 3·7	− 3·7	0·0
18 3 54		− 2·2	−0·3	− 2·9	−5·4		+ 5·5	− 0·4	+5·1
25 10 30		+ 7·4	−0·7	−13·0	−6·3		− 8·5	+10·6	+2·1
26 11 22		+ 4·5	−0·6	− 9·5	−5·6		− 9·8	+10·5	+0·7
27 12 13		+ 4·7	−0·6	− 6·6	−2·5		− 9·2	+ 9·4	+0·2
28 13 2		+ 3·5	−0·6	− 5·3	−2·4		− 8·6	+ 7·6	−1·0
29 13 51		+ 5·0	−0·6	− 4·8	−0·4		− 7·3	+ 5·5	−1·8
Apr. 2 17 4		+ 9·1	−0·6	− 5·6	+2·9		+ 1·6	− 2·5	−0·9
21 8 23		+11·9	−0·9	−16·2	−5·2		−11·1	+10·3	−0·8
22 9 15		+10·9	−0·8	−14·6	−4·5		−10·5	+11·3	+0·8
24 10 53		+ 4·7	−0·5	− 7·4	−3·2		− 6·9	+ 8·8	+1·9
25 11 42		+ 4·7	−0·5	− 4·0	+0·2		− 9·0	+ 6·7	−2·3
27 13 18		+ 3·7	−0·5	− 2·3	+0·9		− 7·2	+ 2·9	−4·3
28 14 7		+ 6·9	−0·5	− 2·6	+3·8		+ 0·4	+ 0·6	+1·0
29 14 56		+ 1·7	−0·3	− 2·8	−1·4		+ 0·5	− 1·1	−0·6

Approx. G.M.T. 1850.	B−O	Longitude. Corr. to B.	H−B	H−O	E.N.P.D. B−O	H−B	H−O
d h m							
May 1 16 33	+ 3·8	−0·4	− 3·0	+0·4	+ 4·1	−4·1	0·0
2 17 20	+ 6·2	−0·5	− 3·0	+2·7	+ 7·9	−5·4	+ 2·5
18 6 20	+ 4·9	−0·6	− 9·7	−5·4	− 8·7	+8·9	+ 0·2
19 7 12	+ 4·6	−0·6	− 9·7	−5·7	−10·9	+9·4	− 1·5
20 8 2	+ 7·2	−0·7	−10·5	−4·0	−10·4	+9·4	− 1·0
21 8 50	+ 8·5	−0·7	−10·2	−2·4	− 7·7	+8·4	+ 0·7
22 9 37	+ 4·7	−0·5	− 9·0	−4·8	− 7·7	+6·4	− 1·3
23 10 24	+ 6·1	−0·5	− 7·0	−1·4	− 4·5	+4·6	+ 0·1
27 13 38	+ 6·4	−0·5	− 4·6	+1·3	+ 1·5	−1·4	+ 0·1
28 14 26	+ 5·6	−0·5	− 3·4	+1·7	+ 1·9	−2·5	− 0·6
30 16 2	+ 4·1	−0·4	− 0·6	+3·1	+ 4·0	−4·6	− 0·6
31 16 48	+ 5·7	−0·5	+ 0·2	+5·4	+ 5·4	−5·7	− 0·3
June 1 17 33	+ 2·4	−0·5	+ 0·6	+2·5	+13·1	−7·0	+ 6·1
2 18 17	− 1·2	−0·5	+ 1·0	−0·7	+17·8	−8·0	+ 9·8
3 19 2	− 3·8	−0·3	+ 1·8	−2·3	+12·4	−8·7	+ 3·7
17 6 49	+ 4·1	−0·5	− 7·9	−4·3	− 6·5	+6·1	− 0·4
18 7 36	+ 2·4	−0·4	− 7·0	−5·0	− 5·6	+4·6	− 1·0
19 8 23	+ 4·2	−0·5	− 6·1	−2·4	− 3·3	+3·0	− 0·3
20 9 9	+ 5·8	−0·5	− 4·9	+0·4	− 2·8	+1·3	− 1·5
21 9 57	+ 3·8	−0·4	− 4·2	−0·8	− 1·0	−0·3	− 1·3
22 10 45	+ 6·4	−0·5	− 4·3	+1·6	+ 2·4	−1·3	+ 1·1
23 11 33	+ 4·6	−0·4	− 4·5	−0·3	+ 4·5	−2·4	+ 2·1
24 12 22	+ 5·0	−0·4	− 5·2	−0·6	+ 3·5	−2·7	+ 0·8
25 13 10	+ 5·8	−0·5	− 4·9	+0·4	+ 4·1	−2·6	+ 1·5
29 16 13	+ 3·4	−0·4	− 0·1	+2·9	+ 6·1	−3·3	+ 2·8
July 1 17 41	+ 5·9	−0·6	− 3·9	+1·4	+ 8·7	−4·4	+ 4·3
4 20 3	+ 3·0	−0·5	− 5·2	−2·7	+ 9·9	−4·8	+ 5·1
14 4 44	+11·2	−0·8	−18·5	−8·1	− 7·1	+6·3	− 0·8
15 5 33	+12·7	−0·8	−13·3	−1·4	− 6·2	+4·8	− 1·4
21 10 18	− 0·9	−0·2	− 0·7	−1·8	+ 5·3	−4·0	+ 1·3
22 11 7	+ 2·9	−0·4	− 0 6	+1·9	+ 3·2	−3·9	− 0·7
25 13 27	+ 6·4	−0 5	− 1·6	+4·3	+ 4·4	−2·5	+ 1·9
26 14 12	(+ 5·8)	(−0·5)	− 1·8	(+3·5)	(+ 2·8)	−1·8	(+ 1·0)
27 14 56	+ 7·3	−0·5	− 2·5	+4·3	+ 3·0	−1·4	+ 1·6
Aug. 3 20 36	(+ 5·5)	−0·5	− 5·7	(−0·7)	(−22·4)	+1·8	(−20·6)
13 5 3	+15·4	−0·8	−15·5	−0·9	− 5·1	+4·9	− 0·2
15 6 39	+ 5·7	−0·5	− 6·8	−1·6	− 4·9	+0·6	− 4·3
18 9 3	+ 0·9	−0·3	− 0·7	−0·1	+ 4·5	−3·4	+ 1·1
19 9 51	− 0·1	−0·3	+ 0·8	+0·4	+ 3·2	−3·8	− 0·6
20 10 39	+ 2·2	−0·4	+ 1·9	+3·7	+ 4·0	−3·8	+ 0·2
21 11 25	+ 3·8	−0·4	+ 1·6	+5·0	+ 4·6	−3·4	+ 1·2

Approx. G.M.T. 1850.			Longitude.			E.N.P.D.		
	B−0	Corr. to B.	H−B	H−0	B−0	H−B	H−0
d h m							
Aug. 22 12 10	+ 3·0	−0·4	+ 0·4	+3·0	+ 3·7	− 2·8	+0·9
23 12 54	+ 5·1	−0·5	− 1·9	+2·7	+ 4·6	− 2·0	+2·6
24 13 38	+ 8·3	−0·6	− 4·0	+3·7	+ 3·4	− 1·4	+2·0
26 15 6	+ 6·3	−0·5	− 7·2	−1·4	+ 0·9	− 0·3	+0·6
28 16 40	+14·5	−0·8	− 9·6	+4·1	+ 1·3	+ 0·1	+1·4
29 17 31	+11·6	−0·7	−11·0	−0·1	− 0·6	+ 0·5	−0·1
30 18 25	+10·9	−0·7	−11·1	−0·9	− 1·3	+ 1·3	0·0
Sept. 11 4 32	+19·8	−1·0	−17·4	+1·4	− 9·0	+ 5·0	−4·0
12 5 21	+12·0	−0·7	−11·0	+0·3	− 3·3	+ 2·9	−0·4
14 6 59	+ 3·7	−0·4	− 4·5	−1·2	0·0	− 0·6	−0·6
18 10 7	+ 1·0	−0·3	− 0·2	+0·5	+ 0·2	− 3·7	−3·5
21 12 20	+ 9·1	−0·6	− 7·3	+1·2	+ 2·8	− 2·3	+0·5
22 13 4	+ 8·5	−0·6	− 9·1	−1·2	+ 4·9	− 1·7	+3·2
25 15 28	+ 7·4	−0·6	− 6·9	−0·1	− 1·2	− 0·1	−1·3
26 16 20	+ 7·7	−0·6	− 7·7	−0·6	+ 0·1	+ 0·3	+0·4
27 17 16	+ 8·3	−0·6	− 9·9	−2·2	+ 0·1	+ 1·4	+1·5
Oct. 11 4 51	+ 9·4	−0·6	−12·2	−3·4	− 6·3	− 0·3	−6·6
12 5 40	+ 3·9	−0·4	− 6·8	−3·3	− 0·7	− 1·6	−2·3
14 7 16	+ 5·6	−0·5	− 2·0	+3·1	+ 4·5	− 4·0	+0·5
15 8 1	− 0·2	−0·3	− 1·6	−2·1	+ 6·3	− 4·8	+1·5
16 8 46	+ 3·9	−0·4	− 2·3	+1·2	+ 4·2	− 5·3	−1·1
17 9 31	(+ 0 1)	−0·4	− 3·9	−4·2	(+11·8)	− 5·5	(+6·3)
18 10 15	+ 7·8	−0·6	− 6·8	+0·4	+ 5·0	− 4·9	+0·1
20 11 45	+15·5	−0·9	−13·3	+1·3	+ 3·8	− 3·2	+0·6
21 12 33	+15·0	−0·9	−14·1	0·0	+ 4·8	− 2·2	+2·6
22 13 23	+16·2	−0·9	−12·6	+2·7	+ 2·2	− 0·5	+1·7
25 16 9	+ 8·2	−0·7	− 8·8	−1·3	− 6·3	+ 3·6	−2·7
26 17 7	+ 9·7	−0·7	−10·4	−1·4	− 2·1	+ 5·7	+3·6
28 19 1	+10·8	−0·8	−13·2	−3·2	− 8·3	+ 9·0	+0·7
Nov. 11 5 55	+ 1·0	−0·4	− 1·7	−1·1	+ 9·3	− 4·7	+4·6
12 6 40	+ 1·0	−0·4	− 0·9	−0·3	+ 4·8	− 5·4	−0·6
13 7 24	− 1·3	−0·3	− 1·8	−3·4	+ 5·4	− 5·8	−0·4
14 8 8	+ 3·4	−0·4	− 3·7	−0·7	+ 5·0	− 5·9	−0·9
24 16 57	+13·6	−1·1	−12·6	−0·1	−13·2	+10·1	−3·1
25 17 52	+13·6	−1·0	−14·6	−2·0	−12·0	+11·5	−0·5
28 20 24	+19·9	−1·1	−17·6	+1·2	− 9·3	+ 8·6	−0·7
Dec. 12 6 45	+ 3·1	−0·4	− 3·9	−1·2	+ 2·6	− 2·8	−0·2
17 10 46	+11·2	−0·8	−15·2	−4·8	+ 4·5	+ 0·5	+5·0
19 12 46	+18·0	−1·1	−17·9	−1·0	− 3·8	+ 3·5	−0·3
20 13 47	+17·8	−1·1	−17·3	−0·6	− 2·6	+ 5·3	+2·7
21 14 48	+16·0	−1·1	−15·4	−0·5	− 7·4	+ 7·4	0·0
22 15 46	+15·6	−1·1	−14·2	+0·3	− 7·3	+ 8·8	+1·5
27 19 59	+16·2	−0 9	−15·4	−0·1	− 2·6	+ 2·9	+0·3

Approx. G.M.T. 1851.			Longitude.				E.N.P.D.		
d h m		B−O	Corr. to B.	H−B	H−O		B−O	H−B	H−O
Jan. 8 4 40		− 0.5	−0.2	− 1.6	−2.3		0.0	+0.5	+0.5
9 5 23		+ 0.8	−0.3	− 2.3	−1.8		− 0.3	+1.0	+0.7
18 13 31		+17.3	−1.2	−20.5	−4.4		− 9.9	+7.2	−2.7
21 16 17		+11.8	−0.8	−14.4	−3.4		− 6.6	+5.1	−1.5
22 17 8		+18.0	−1.0	−14.0	+3.0		− 4.9	+3.6	−1.3
24 18 45		+12.1	−0.7	−11.6	−0.2		− 1.1	−1.5	−2.6
26 20 23		+ 2.9	−0.3	− 2.7	−0.1		+ 9.6	−5.3	+4.3
Feb. 8 5 31		+ 0.2	−0.2	− 2.6	−2.6		− 2.0	+1.0	−1.0
10 7 11		+ 2.8	−0.3	−10.2	−7.7		− 8.6	+2.1	−6.5
11 8 6		+ 8.0	−0.6	−14.8	−7.4		− 3.7	+3.1	−0.6
13 10 6		+17.5	−1.1	−20.1	−3.7		− 5.4	+6.0	+0.6
14 11 8		+16.1	−1.0	−20.4	−5.3		− 4.1	+7.1	+3.0
15 12 9		+18.1	−1.2	−20.5	−3.6		− 8.9	+7.9	−1.0
16 13 8		+18.3	−1.2	−19.9	−2.8		− 5.5	+7.6	+2.1
21 17 29		+ 3.8	−0.4	− 5.4	−2.0		+ 2.0	−1.6	+0.4
22 18 19		+ 4.8	−0.4	− 4.0	+0.4		+ 2.8	−3.6	−0.8
Mar. 11 6 52		+ 3.9	−0.4	−13.0	−9.5		− 2.4	+1.6	−0.8
13 8 50		+14.8	−0.9	−18.2	−4.3		− 5.9	+6.0	+0.1
14 9 49		+ 9.3	−0.7	−17.0	−8.4		− 6.4	+8.0	+1.6
16 11 45		+12.5	−0.9	−15.1	−3.5		− 7.1	+9.0	+1.9
18 13 34		+11.3	−0.9	−12.7	−2.3		− 8.4	+7.0	−1.4
20 15 18		+ 2.8	−0.4	− 6.6	−4.2		− 2.0	+3.4	+1.4
Apr. 9 6 40		+ 12.0	−0.8	−17.8	−6.6		− 5.9	+5.2	−0.7
10 7 38		+10.4	−0.7	−19.3	−9.6		− 6.7	+7.3	+0.6
12 9 30		+10.4	−0.8	−16.5	−6.9		−10.0	+9.9	−0.1
13 10 25		+ 7.2	−0.7	−13.7	−7.2		− 8.6	+9.8	+1.2
14 11 18		+ 9.1	−0.8	−11.2	−2.9		−10.6	+9.2	−1.4
17 13 56		+ 5.7	−0.5	− 7.7	−2.5		− 3.9	+5.1	+1.2
18 14 49		+ 7.6	−0.6	− 7.1	−0.1		− 1.0	+3.2	+2.2
20 16 35		+ 4.1	−0.4	− 5.8	−2.1		+ 1.2	−0.8	+0.4
May 8 6 29		+11.2	−0.8	−18.0	−7.6		− 8.2	+8.4	+0.2
10 8 16		+11.8	−0.9	−18.0	−7.1		−10.7	+9.1	−1.6
13 10 51		+ 5.5	−0.6	−11.2	−6.3		− 4.0	+5.4	+1.4
14 11 43		+ 6.0	−0.6	− 9.2	−3.8		− 1.8	+4.2	+2.4
15 12 36		+ 9.1	−0.7	− 8.6	−0.2		− 3.1	+3.0	−0.1
19 16 7		+ 5.7	−0.5	− 6.0	−0.8		+ 4.5	−2.0	+2.5
22 18 27		+ 2.9	−0.4	− 1.8	+0.7		+ 5.0	−4.8	+0.2
23 19 10		+ 2.5	−0.3	− 0.1	+2.1		− 1.4	−5.0	−6.4

Approx. G.M.T. 1851			Longitude.				R.N.P.D.		
d	h	m	B−O	Corr. to B.	H−B	H−O	B−O	H−B	H−O
June 13	12	12	+ 8.6	−0.6	− 9.3	−1.3	0.0	−1.3	−1.3
14	13	5	+ 8.4	−0.6	− 9.0	−1.2	+4.1	−1.5	+2.6
16	14	48	+ 4.7	−0.4	− 5.5	−1.2	+2.0	−1.3	+0.7
17	15	35	+ 3.0	−0.4	− 2.8	−0.2	+1.7	−1.1	+0.6
18	16	21	+ 3.0	−0.4	− 1.1	+1.5	−0.8	−1.0	−1.8
20	17	47	+ 3.6	−0.4	− 1.1	+2.1	+2.7	−0.9	+1.8
22	19	11	+ 2.6	−0.4	− 1.9	+0.3	+0.4	−1.2	−0.8
July 3	4	9	+19.6	−1.1	−28.2	−9.7	−6.6	+5.0	−1.6
7	7	32	+ 3.7	−0.5	−10.2	−7.0	−1.0	+0.8	−0.2
10	10	5	+ 3.6	−0.4	− 7.5	−4.3	+2.9	−3.2	−0.3
12	11	50	+ 6.6	−0.5	− 7.4	−1.3	+4.3	−3.4	+0.9
14	13	29	+ 7.5	−0.5	− 5.6	+1.4	−0.3	−1.5	−1.8
15	14	16	+ 3.5	−0.4	− 3.3	−0.2	+0.6	−0.5	+0.1
17	15	43	− 0.9	−0.3	+ 0.6	−0.6	+0.7	+1.7	+2.4
18	16	25	+ 3.6	−0.4	+ 0.7	+3.9	−1.9	+2.2	+0.3
20	17	49	+ 6.3	−0.5	− 2.9	+2.9	−1.7	+2.3	+0.6
21	18	33	+ 9.7	−0.6	− 4.8	+4.3	−2.7	+2.1	−0.6
Aug. 3	5	29	+12.0	−0.8	−17.4	−6.2	−3.1	+3.3	+0.2
5	7	10	+ 7.8	−0.6	− 8.2	−1.0	−1.3	+0.4	−0.9
7	8	53	− 2.4	−0.2	− 3.9	−6.5	+1.2	−2.1	−0.9
8	9	45	+ 1.7	−0.4	− 3.2	−1.9	+2.4	−2.8	−0.4
11	12	12	+ 6.9	−0.5	− 5.6	+0.8	+1.5	−1.8	−0.3
12	12	57	+ 6.2	−0.4	− 6.0	−0.2	−0.7	−0.5	−1.2
13	13	41	+ 7.7	−0.5	− 5.2	+2.0	+0.9	+1.1	+2.0
15	15	4	+ 6.1	−0.4	− 2.0	+3.7	−1.2	+2.9	+1.7
18	17	12	+ 6.5	−0.5	− 5.2	+0.8	−2.7	+3.4	+0.7
20	18	50	+13.0	−0.7	− 9.6	+2.7	−6.0	+4.0	−2.0
31	4	13	+21.4	−1.2	−26.7	−6.5	−5.7	+4.6	−1.1
Sept. 3	6	50	+ 7.4	−0.6	− 8.2	−1.4	−1.0	+0.5	−0.5
8	10	55	+ 2.0	−0.4	− 4.2	−2.6	+1.6	−1.1	+0.5
9	11	39	+ 7.0	−0.5	− 6.9	−0.4	+1.7	−0.6	+1.1
10	12	21	+10.4	−0.6	− 9.2	+0.6	+0.2	+0.7	+0.9
11	13	3	+ 8.3	−0.5	−10.1	−2.3	−2.8	+1.9	−0.9
12	13	44	+14.0	−0.7	− 9.3	+4.0	−0.3	+2.7	+2.4
13	14	26	+13.4	−0.7	− 7.9	+4.8	−1.7	+3.2	+1.5
14	15	10	+10.4	−0.6	− 7.0	+2.8	−2.0	+3.4	+1.4
15	15	55	+ 3.8	−0.4	− 7.1	−3.7	−3.2	+3.3	+0.1
17	17	34	+ 8.7	−0.6	−11.7	−3.6	−5.3	+4.1	−1.2
30	4	43	+18.4	−1.0	−19.7	−2.3	−3.3	−0.3	−3.6

Approx. G.M.T. 1851.		B−O	Longitude. Corr. to B.	H−B	H−O	E.N.P.D. B−O	H−B	H−O
	d h m	+ ″	− ″	− ″	+ ″	− ″	− ″	− ″
Oct. 2	6 28	+ 9·0	−0·6	− 8·1	+0·3	−1·1	−2·4	−3·5
3	7 19	+ 3·9	−0·4	− 5·4	−1·9	+1·2	−2·9	−1·7
4	8 7	+ 4·8	−0·4	− 4·4	0·0	+2·2	−3·0	−0·8
5	8 53	+ 4·0	−0·4	− 5·3	−1·7	+1·4	−2·7	−1·3
8	11 2	+10·1	−0·6	−10·1	−0·6	+2·5	+0·4	+2·9
10	12 25	+20·8	−0·9	−13·5	+6·4	−0·1	+2·5	+2·4
11	13 8	+18·6	−0·9	−13·9	+3·8	−2·3	+2·8	+0·5
14	15 30	+11·3	−0·7	− 9·4	+1·2	−6·2	+3·5	−2·7
15	16 23	+ 3·8	−0·4	− 9·8	−6·4	−5·2	+4·1	−1·1
16	17 18	+ 9·0	−0·6	−12·1	−3·7	−3·5	+5·3	+1·8
17	18 14	+18·0	−1·0	−14·9	+2·1	−7·9	+6·5	−1·4
18	19 11	+14·0	−0·9	−16·7	−3·6	−6·1	+7·2	+1·1
30	5 12	+ 7·9	−0·6	− 9·7	−2·4	+3·3	−5·1	−1·8
Nov. 1	6 50	+ 3·4	−0·4	− 4·8	−1·8	+3·4	−4·5	−1·1
2	7 35	+ 5·2	−0·5	− 5·7	−1·0	+4·6	−3·7	+0·9
3	8 18	+ 6·3	−0·5	− 7·3	−1·5	+3·3	−2·7	+0·6
4	9 0	+ 9·4	−0·6	− 8·9	−0·1	+3·2	−1·5	+1·7
6	10 23	+10·3	−0·5	−11·0	−1·2	−1·9	+0·9	−1·0
7	11 6	+11·0	−0·6	−12·6	−2·2	−2·4	+1·6	−0·8
14	17 5	+11·3	−0·8	−10·7	−0·2	−7·3	+6·7	−0·6
15	18 0	+10·0	−0·8	−14·6	−5·4	−7·1	+7·5	+0·4
16	18 54	+16·3	−1·0	−17·6	−2·3	−9·8	+7·3	−2·5
17	19 47	+21·7	−1·2	−18·0	+2·5	−8·3	+5·7	−2·6
29	5 29	− 3·6	−0·1	− 3·4	−7·1	+1·5	−3·4	−1·9
30	6 14	+ 1·8	−0·3	− 3·2	−1·7	−0·2	−2·1	−2·3
Dec. 2	7 37	+ 5·6	−0·4	− 6·2	−1·0	+0·8	+0·7	+1·5
5	9 44	+ 4·6	−0·3	− 9·3	−5·0	−9·0	+2·9	−6·1
7	11 20	+12·2	−0·7	−13·0	−1·5	−3·9	+3·1	−0·8
8	12 12	+10·0	−0·7	−14·5	−5·2	−4·4	+3·2	−1·2
10	14 4	+13·1	−0·9	−11·5	+0·7	−4·4	+4·4	0·0
11	15 1	+ 8·3	−0·7	− 9·6	−2·0	−4·5	+5·0	+0·5
30	6 14	+ 0·1	−0·2	− 3·4	−3·5	−2·8	+2·6	−0·2

Approx. G.M.T. 1852.			B−O	Longitude.			E.N.P.D.		
				Corr. to B.	H−B	H−O	B−O	H−B	H−O
	d	h	m							
Jan.	3	9	9	+ 7˙1	− 0˙5	− 9˙2	− 2˙6	− 5˙2	+ 5˙5	+ 0˙3
	4	10	0	+ 9˙8	− 0˙6	− 11˙2	− 2˙0	− 6˙4	+ 5˙5	− 0˙9
	5	10	54	+ 9˙8	− 0˙7	− 12˙8	− 3˙7	− 6˙1	+ 5˙8	− 0˙3
	6	11	51	+ 11˙9	− 0˙8	− 14˙4	− 3˙3	− 5˙1	+ 5˙8	+ 0˙7
	7	12	50	+ 15˙1	− 1˙0	− 15˙1	− 1˙0	− 5˙5	+ 5˙9	+ 0˙4
	9	14	45	+ 14˙3	− 1˙0	− 15˙2	− 1˙9	− 6˙4	+ 5˙2	− 1˙2
	11	16	32	+ 16˙1	− 0˙9	− 17˙0	− 1˙8	− 2˙4	+ 3˙5	+ 1˙1
	25	3	28	− 1˙7	− 0˙2	− 0˙2	− 2˙1	− 0˙8	− 0˙1	− 0˙9
	26	4	9	− 1˙3	− 0˙2	− 0˙1	− 1˙6	+ 1˙2	+ 1˙6	+ 2˙8
	28	5	31	− 0˙1	− 0˙2	− 2˙6	− 2˙9	− 3˙7	+ 3˙5	− 0˙2
	29	6	14	+ 3˙3	− 0˙3	− 5˙1	− 2˙1	− 6˙4	+ 4˙7	− 1˙7
	30	6	59	+ 5˙3	− 0˙4	− 7˙8	− 2˙9	− 6˙6	+ 5˙1	− 1˙5
Feb.	1	8	39	+ 7˙8	− 0˙5	− 11˙5	− 4˙2	− 8˙3	+ 6˙2	− 2˙1
	2	9	34	+ 9˙8	− 0˙7	− 12˙5	− 3˙4	− 2˙1	+ 6˙7	+ 4˙6
	3	10	32	+ 9˙9	− 0˙7	− 13˙1	− 3˙9	− 5˙4	+ 6˙5	+ 1˙1
	6	13	28	+ 18˙1	− 1˙1	− 17˙4	− 0˙4	− 5˙5	+ 4˙4	− 1˙1
	9	16	8	+ 13˙4	− 0˙8	− 12˙9	− 0˙3	− 1˙2	− 0˙3	− 1˙5
	11	17	51	+ 10˙1	− 0˙6	− 10˙9	− 1˙4	+ 3˙3	− 3˙9	− 0˙6
	25	4	9	− 1˙7	− 0˙1	− 0˙7	− 2˙5	− 3˙4	+ 2˙2	− 1˙2
	27	5	39	+ 2˙4	− 0˙3	− 6˙4	− 4˙3	− 4˙2	+ 3˙0	− 1˙2
	29	7	20	+ 5˙9	− 0˙5	− 11˙7	− 6˙3	− 6˙1	+ 5˙0	− 1˙1
Mar.	2	9	13	+ 11˙9	− 0˙8	− 12˙7	− 1˙6	− 3˙9	+ 6˙8	+ 2˙9
	3	10	11	+ 8˙3	− 0˙7	− 12˙3	− 4˙7	− 5˙8	+ 6˙9	+ 1˙1
	4	11	9	+ 11˙3	− 0˙9	− 13˙1	− 2˙7	− 6˙2	+ 6˙1	− 0˙1
	5	12	6	+ 13˙0	− 0˙9	− 14˙3	− 2˙2	− 3˙9	+ 4˙7	+ 0˙8
	6	13	2	+ 12˙5	− 0˙8	− 15˙1	− 3˙4	− 1˙3	+ 3˙0	+ 1˙7
	28	6	5	+ 4˙2	− 0˙4	− 10˙6	− 6˙8	− 5˙2	+ 4˙7	− 0˙5
	30	7	56	+ 14˙7	− 0˙9	− 13˙5	+ 0˙3	− 9˙3	+ 7˙5	− 1˙8
Apr.	1	9	48	+ 8˙3	− 0˙7	− 13˙3	− 5 7	− 6˙3	+ 8˙1	+ 1˙8
	2	10	44	+ 10˙5	− 0˙9	− 12˙6	− 3˙0	− 7˙9	+ 7˙1	− 0˙8
	3	11	38	+ 11˙0	− 0 9	− 12˙8	− 2˙7	− 4˙8	+ 5˙6	+ 0˙8
	4	12	33	+ 11˙6	− 0˙8	− 12˙7	− 1˙9	− 0˙6	+ 3˙8	+ 3˙2
	5	13	28	+ 10˙8	− 0˙7	− 12˙5	− 2˙4	+ 0˙5	+ 2˙0	+ 2˙5
	26	5	48	+ 4˙2	− 0˙5	− 12˙1	− 8˙4	− 7˙6	+ 6˙8	− 0˙8
	27	6	42	+ 5˙0	− 0˙6	− 13˙7	− 9˙3	− 7˙8	+ 7˙8	0˙0
May	1	10	16	+ 7 8	− 0˙7	− 12˙7	− 5˙6	− 5˙4	+ 5˙5	+ 0˙1

Approx. G.M.T. 1852.			Longitude.				E.N.P.D.		
			B−O	Corr. to B.	H−B	H−O	B−O	H−B	H−O
	d	h	m							
May 2	11	10	+ 8·6″	−0·8″	− 12·3″	−4·5″	−0·6″	+3·9″	+3·3″
3	12	6	+10·7	−0·8	− 13·2	−3·3	0·0	+2·2	+2·2
4	13	3	+10·6	−0·8	− 14·2	−4·4	−2·2	+0·9	−1·3
7	15	58	+ 6·1	−0·5	− 6·4	−0·8	+1·7	−1·6	+0·1
24	4	38	+ 7·1	−0·6	− 14·1	−7·6	−6·0	+5·2	−0·8
31	10	46	+ 7·8	−0·7	− 11·3	−4·2	+0·8	−1·4	−0·6
June 4	14	40	+ 7·9	−0·6	− 9·1	−1·8	+0·5	−2·9	−2·4
22	4	21	+11·8	−0·9	− 19·3	−8·4	−6·2	+2·9	−3·3
26	7	43	+ 5·5	−0·5	− 12·3	−7·3	−1·1	−0·9	−2·0
27	8	36	+ 4·0	−0·4	− 11·0	−7·4	+2·2	−2·6	−0·4
29	10	27	+ 5·2	−0·5	− 9·6	−4·9	+5·6	−5·7	−0·1
July 1	12	24	+ 5·3	−0·5	− 7·8	−3·0	+5·9	−6·0	−0·1
2	13	21	+ 6·2	−0·6	− 6·9	−1·3	+8·3	−5·1	+3·2
3	14	15	+ 3·5	−0·5	− 6·2	−3·2	+5·6	−3·8	+1·8
4	15	5	+ 9·0	−0·6	− 5·5	+2·9	+2·7	−1·8	+0·9
6	16	35	+ 7·2	−0·5	− 3·1	+3·6	−1·2	+1·6	+0·4
8	17	58	+ 6·1	−0·4	− 1·9	+3·8	−3·4	+3·9	+0·5
9	18	39	+ 4·8	−0·4	− 2·1	+2·3	−5·9	+4·6	−1·3
10	19	21	+ 4·5	−0·4	− 1·8	+2·3	−4·2	+4·7	+0·5
23	5	40	+ 9·7	−0·7	− 15·8	−6·8	−2·8	+1·9	−0·9
27	9	16	+ 8·9	−0·7	− 10·1	−1·9	+3·4	−4·4	−1·0
30	12	4	+ 5·6	−0·5	− 9·5	−4·4	+5·3	··5·9	−0·6
31	12	56	+ 9·9	−0·7	− 9·8	−0·6	+6·0	−4·5	+1·5
Aug. 2	14	29	+11·7	−0·7	− 7·8	+3·2	+0·2	−1·0	−0·8
3	15	12	+ 7·9	−0·6	− 4·4	+2·9	+1·0	+0·7	+1·7
4	15	54	+ 8·1	−0·5	− 1·2	+6·4	−0·1	+1·8	+1·7
7	17	58	+ 8·6	−0·5	− 1·0	+7·1	−8·3	+3·9	−4·4
9	19	31	+ 3·5	−0·4	− 2·7	+0·4	−5·4	+5·2	−0·2
22	6	15	+ 5·1	−0·5	− 10·5	−5·9	−2·9	+1·5	−1·4
26	9	58	+11·1	−0·7	− 8·9	+1·5	+3·7	−3·6	+0·1
28	11	38	+13·9	−0·8	− 13·5	−0·4	+4·2	−2·9	+1·3
29	12	24	+16·9	−0·8	− 15·2	+0·9	+2·7	−1·6	+1·1
30	13	8	+18·1	−0·8	− 14·9	+2·4	+0·7	−0·1	+0·6
31	13	50	+15·0	−0·7	− 11·6	+2·7	−0·8	+1·0	+0·2
Sept. 1	14	31	+10·9	−0·6	− 6·8	+3·5	0·0	+1·8	+1·8
2	15	12	+ 7·3	−0·5	− 2·6	+4·2	−1·2	+2·2	+1·0
23	8	46	+ 4·9	−0·5	− 5·6	−1·2	+1·7	−3·1	−1·4
24	9	35	+ 5·2	−0·5	− 7·0	−2·3	+0·6	−2·2	−1·6
25	10	22	+ 8·0	−0·6	− 9·3	−1·9	+4·1	−1·1	+3·0
29	13	9	+18·2	−0·8	− 13·2	+4·2	−2·0	+3·3	+1·3

f

Errors of Hansen's Tables deduced

Approx. G.M.T. 1852.			Longitude.				E.N.P.D.		
			B−O	Corr. to B.	H−B	H−O	B−O	H−B	H−O
	d	h m							
Oct.	2	15 18	+ 5·4	−0·4	− 3·0	+2·0	− 4·7	+4·0	−0·7
	3	16 5	+ 7·1	−0·5	− 2·5	+4·1	− 6·8	+4·5	−2·3
	4	16 55	+ 5·6	−0·4	− 4·4	+0·8	− 7·2	+5·6	−1·6
	6	18 41	+13·5	−0·8	−12·8	−0·1	−10·8	+8·7	−2·1
	18	4 52	+10·9	−0·7	−17·2	−7·0	+ 5·0	−6·8	−1·8
	19	5 49	+10·3	−0·7	−11·8	−2·2	+ 4·4	−6·9	−2·5
	20	6 43	+ 8·9	−0·6	− 8·9	−0·6	+ 3·4	−6·3	−2·9
	23	9 5	+ 7·9	−0·5	− 7·2	+0·2	+ 1·9	−1·2	+0·7
	24	9 47	+ 7·6	−0·5	− 7·4	−0·3	+ 0·7	+0·4	+1·1
	25	10 28	+ 9·3	−0·5	− 8·3	+0·5	− 2·1	+1·9	−0·2
	26	11 8	+10·8	−0·6	− 9·8	+0·4	− 0·7	+3·2	+2·5
	28	12 32	+14·6	−0·7	−12·5	+1·4	− 4·2	+4·1	−0·1
	29	13 16	+13·9	−0·7	−11·7	+1·5	− 3·8	+4·0	+0·2
	31	14 51	+ 8·3	−0·6	− 7·0	+0·7	− 5·6	+4·1	−1·5
Nov.	2	16 34	+ 5·4	−0·5	− 6·4	−1·5	− 5·6	+5·4	−0·2
	3	17 27	+ 9·3	−0·7	− 9·8	−1·2	− 8·2	+6·2	−2·0
	17	5 28	+ 4·1	−0·5	−10·8	−7·2	+ 4·5	−6·2	−1·7
	18	6 17	+ 5·9	−0·5	− 9·7	−4·3	+ 5·2	−4·4	+0·8
	24	10 30	+ 7·9	−0·5	− 6·6	+0·8	− 4·0	+5·0	+1·0
	26	11 59	+ 9·5	−0·6	− 9·1	−0·2	− 6·3	+4·9	−1·4
	27	12 48	+10·1	−0·6	− 9·9	−0·4	− 6·5	+4·6	−1·9
	28	13 38	+ 9·7	−0·6	− 9·8	−0·7	− 4·3	+4·3	0·0
	29	14 30	+ 8·2	−0·6	− 8·0	−0·4	− 3·0	+3·9	+0·9
	30	15 23	+ 5·6	−0·5	− 6·6	−1·5	− 4·1	+3·8	−0·3
Dec.	2	17 7	+ 8·9	−0·6	− 7·9	+0·4	− 3·8	+4·3	+0·5
	15	4 9	+10·2	−0·7	− 8·7	+0·8	+ 2·9	−5·1	−2·2
	17	5 42	+ 7·1	−0·5	− 6·9	−0·3	+ 0·5	−0·5	0·0
	18	6 24	+ 6·4	−0·4	− 7·4	−1·4	− 0·4	+1·7	+1·3
	20	7 46	+ 6·3	−0·4	− 9·0	−3·1	− 6·4	+5·6	−0·8
	21	8 27	+10·4	−0·5	− 8·8	+1·1	− 6·4	+6·5	+0·1
	27	13 18	+ 7·7	−0·6	− 8·8	−1·7	− 6·4	+5·6	−0·8
	28	14 12	+ 6·5	−0·5	− 8·6	−2·6	− 2·8	+4·8	+2·0
	30	15 55	+ 6·6	−0·6	− 7·5	−1·5	− 2·7	+3·9	+1·2

Approx. G.M.T. 1853.			B−O	Longitude. Corr. to B.	H−B	H−O	E.N.P.D. B−O	H−B	H−O
	d	h m							
Jan. 3	19	11	+ 6.8	−0.6	−10.3	−4.1	+ 0.3	−0.5	−0.2
4	20	3	+ 3.4	−0.4	− 6.7	−3.7	+ 3.5	−2.4	+1.1
15	5	0	+ 4.2	−0.4	− 3.7	+0.1	− 0.3	+0.7	+0.4
18	7	5	+ 9.0	−0.5	− 9.0	−0.5	− 6.2	+5.9	−0.3
20	8	35	+ 8.4	−0.5	− 7.9	0.0	− 8.8	+7.6	−1.2
21	9	24	+ 3.2	−0.3	− 5.8	−2.9	− 9.5	+8.0	−1.5
22	10	16	+ 0.6	−0.3	− 4.5	−4.2	− 8.5	+7.8	−0.7
23	11	9	+ 5.2	−0.5	− 4.9	−0.2	− 7.2	+7.5	+0.3
26	13	50	+ 6.2	−0.6	− 9.7	−4.1	− 4.3	+4.8	+0.5
30	17	8	+ 7.4	−0.7	−12.9	−6.2	− 2.2	+0.3	−1.9
31	17	59	+10.2	−0.6	−14.0	−4.4	+ 6.3	−1.8	+4.5
Feb. 14	4	59	+ 5.7	−0.4	− 3.9	+1.4	− 2.3	+2.2	−0.1
15	5	42	+ 4.4	−0.3	− 6.0	−1.9	− 7.2	+3.9	−3.3
16	6	27	+ 7.8	−0.5	− 7.4	−0.1	− 6.1	+5.1	−1.0
19	8	57	+ 3.4	−0.4	− 3.7	−0.7	− 6.7	+7.6	+0.9
21	10	45	+ 2.8	−0.5	− 2.8	−0.5	− 7.7	+6.9	−0.8
23	12	31	+ 3.7	−0.5	− 6.5	−3.3	− 3.0	+4.5	+1.5
27	15	55	+ 8.9	−0.6	−12.7	−4.4	+ 2.3	−2.6	−0.3
28	16	48	+10.7	−0.7	−13.0	−3.0	+ 4.2	−4.6	−0.4
Mar. 18	6	46	+ 0.7	−0.3	− 4.9	−4.5	− 7.7	+7.5	−0.2
19	7	38	+ 1.2	−0.3	− 3.8	−2.9	− 8.9	+8.3	−0.6
20	8	32	+ 0.7	−0.3	− 2.7	−2.3	− 7.9	+8.7	+0.8
22	10	18	− 2.6	−0.3	− 1.7	−4.6	− 5.9	+7.4	+1.5
23	11	9	− 1.0	−0.3	− 3.1	−4.4	− 4.6	+6.1	+1.5
24	12	1	+ 6.0	−0.6	− 5.8	−0.4	− 2.7	+4.1	+1.4
25	12	52	+ 7.4	−0.6	− 9.7	−2.9	− 0.9	+1.9	+1.0
26	13	45	+ 9.1	−0.7	−12.8	−4.4	− 1.1	−0.7	−1.8
27	14	39	+12.1	−0.8	−13.8	−2.5	+ 4.5	−3.1	+1.4
28	15	36	+ 8.9	−0.6	−12.4	−4.1	+ 7.4	−5.2	+2.2
29	16	34	+ 6.1	−0.5	− 9.9	−4.3	+ 7.9	−7.3	+0.6
30	17	34	+ 7.5	−0.6	− 7.5	−0.6	+ 9.9	−8.7	+1.2
31	18	33	+ 7.6	−0.7	− 5.5	+1.4	+ 4.5	−9.4	−4.9
Apr. 1	19	30	+ 1.7	−0.5	− 2.9	−1.7	+14.1	−8.9	+5.2
17	7	13	+ 2.8	−0.4	− 5.8	−3.4	− 9.5	+8.9	−0.6
20	9	46	− 0.5	−0.3	− 6.2	−7.0	− 6.0	+7.6	+1.6
23	12	24	+10.6	−0.8	−14.8	−5.0	− 0.2	+1.6	+1.4
26	15	22	+ 9.5	−0.7	−12.5	−3.7	+ 4.7	−5.1	−0.4

f 2

Approx. G.M.T. 1853.			Longitude.			E.N.P.D	
	B−O	Corr. to B.	H−B	H−O	B−O	H−B	H−O
d h m	"	"	"	"	"	"	"
Apr. 27 16 24	+ 8·1	−0·7	− 8·2	− 0·8	+4·9	−5·9	−1·0
May 14 5 7	+ 5·8	−0·5	− 8·8	− 3·5	−6·5	+5·5	−1·0
16 6 47	+ 4·7	−0·5	− 9·8	− 5·6	−4·7	+5·7	+1·0
18 8 25	+ 5·1	−0·5	−11·1	− 6·5	−3·7	+4·7	+1·0
19 9 15	+ 4·2	−0·4	−11·5	− 7·7	−2·4	+3·6	+1·2
20 10 7	+ 7·4	−0·6	−12·4	− 5·6	−2·9	+2·2	−0·7
21 11 2	+ 8·4	−0·6	−14·5	− 6·7	+2·5	+0·4	+2·9
22 12 1	+13·9	−0·9	−17·0	− 4·0	+3·8	−1·8	+2·0
23 13 3	+12·5	−0·9	−17·4	− 5·8	+6·5	−3·6	+2·9
25 15 10	+13·0	−1·0	−12·4	− 0·4	+6·2	−4·6	+1·6
26 16 10	+ 7·2	−0·7	− 8·8	− 2·3	+6·6	−3·6	+3·0
June 14 6 18	+ 7·3	−0·5	−13·1	− 6·3	−1·6	+1·6	0·0
16 7 55	+ 6·8	−0·5	−12·9	− 6·6	+0·4	−0·6	−0·2
17 8 47	+ 7·6	−0·5	−12·0	− 4·9	+2·2	−2·2	0·0
18 9 42	+ 5·1	−0·5	−11·1	− 6·5	+2·7	−3·9	−1·2
21 12 49	+ 8·1	−0·8	−11·9	− 4·6	+8·2	−7·8	+0·4
23 14 52	+14·0	−0·9	−10·9	+ 2·2	−1·7	−6·0	−7·7
28 18 47	+ 5·5	−0·4	− 3·4	+ 1·7	−3·2	+4·0	+0·8
July 11 4 16	+14·6	−0·8	−17·8	− 4·0	−2·3	+2·7	+0·4
12 5 3	+10·8	−0·7	−17·1	− 7·0	−2·4	+2·3	−0·1
15 7 31	+ 3·9	−0·4	−13·9	−10·4	+2·5	−1·7	+0·8
17 9 27	+ 1·9	−0·3	− 9·6	− 8·0	+8·8	−6·5	+2·3
19 11 33	+10·1	−0·8	−10·3	− 1·0	+9·5	−9·5	0·0
22 14 25	+15·0	−1·0	−13·5	+ 0·5	+9·5	−7·3	+2·2
24 15 59	+13·3	−0·9	− 9·9	+ 2·5	+6·4	−3·4	+3·0
28 18 49	+ 7·6	−0·5	− 3·3	+ 3·8	−5·5	+3·5	−2·0
Aug. 9 3 48	+18·4	−0·9	−22·1	− 4·6	−3·9	+4·9	+1·0
10 4 36	+14·8	−0·9	−19·6	− 5·7	−4·0	+4·5	+0·5
11 5 27	+12·4	−0·8	−17·2	− 5·6	−3·4	+3·4	0·0
13 7 17	+ 9·5	−0·7	−13·0	− 4·2	−0·2	−0·5	−0·7
17 11 18	+17·4	−1·1	−18·2	− 1·9	+8·0	−6·6	+1·4
18 12 13	+16·5	−1·0	−20·2	− 4·7	+5·2	−6·3	−1·1
23 16 1	+ 8·0	−0·6	− 7·7	− 0·3	−0·3	−1·1	−1·4
24 16 44	+ 7·7	−0·6	− 4·1	+ 3·0	+1·1	+0·3	+1·4
25 17 28	+ 4·8	−0·4	− 2·2	+ 2·2	−3·3	+1·6	−1·7
26 18 14	+ 2·5	−0·3	− 1·3	+ 0·9	−3·8	+2·9	−0·9
27 19 2	+ 3·2	−0·4	− 1·4	+ 1·4	−6·1	+4·3	−1·8
Sept. 10 6 10	+ 2·7	−0·4	−10·8	− 8·5	+2·2	−0·2	+2·0
13 9 9	+12·7	−0·8	−15·5	− 3·6	−0·2	−2·7	−2·9

Approx. G.M.T. 1853.			Longitude.			E.N.P.D.		
			B–O	Corr. to B.	H–B	H–O	B–O	H–B	H–O
d h m			"	"	"	"	"	"	"
Sept. 16 11 43			+22·9	−1·1	−21·9	−0·1	+1·3	−1·0	+0·3
17 12 28			+22·2	−1·0	−21·8	−0·6	−1·2	−0·4	−1·6
18 13 12			+20·6	−0·9	−20·0	−0·3	−0·2	0·0	−0·2
20 14 37			+16·7	−0·9	−10·2	+5·6	+2·6	+1·0	+3·6
21 15 21			+ 7·4	−0·5	− 4·2	+2·7	−0·4	+1·4	+1·0
23 16 54			− 2·6	−0·2	+ 2·1	−0·7	−3·6	+3·3	−0·3
25 18 34			+ 0·9	−0·3	− 2·0	−1·4	−6·2	+6·2	0·0
Oct. 9 6 6			+ 8·6	−0·6	−12·4	−4·4	+5·7	−5·3	+0·4
14 10 24			+16·4	−0·8	−13·6	+2·0	+0·5	+0·3	+0·8
15 11 7			+15·7	−0·8	−14·7	+0·2	−1·2	+1·2	0·0
16 11 50			+17·5	−0·8	−15·7	+1·0	−0·2	+2·2	+2·0
18 13 16			+12·1	−0·6	−12·5	−1·0	−3·8	+2·6	−1·2
20 14 48			+ 2·7	−0·4	− 1·6	+0·7	−2·8	+2·7	−0·1
23 17 17			− 4·1	−0·1	+ 1·0	−3·2	−4·1	+4·5	+0·4
24 18 7			+ 7·6	−0·6	− 3·8	+3·2	−6·1	+5·5	−0·6
25 18 57			+ 7·1	−0·6	− 9·1	−2·6	−4·6	+6·1	+1·5
26 19 46			+18·8	−1·0	−13·5	+4·3	−6·9	+6·6	−0·3
Nov. 9 7 38			+15·1	−0·8	−14·3	0·0	+5·3	−2·7	+2·6
10 8 23			+10·4	−0·6	−11·5	−1·7	+0·5	−0·8	−0·3
11 9 6			+ 9·9	−0·6	− 8·8	+0·5	+1·0	+0·8	+1·8
16 12 43			+12·9	−0·7	− 9·3	+2·9	−3·9	+3·1	−0·8
17 13 31			+ 6·8	−0·5	− 7·4	−1·1	−3·1	+2·6	−0·5
18 14 21			+ 4·1	−0·4	− 4·5	−0·8	−2·8	+2·0	−0·8
19 15 11			+ 2·2	−0·4	− 1·7	+0·1	−1·0	+1·5	+0·5
20 16 1			− 1·0	−0·3	− 0·9	−2·2	−3·6	+1·6	−2·0
21 16 51			+ 1·3	−0·4	− 2·2	−1·3	−5·1	+1·9	−3·2
Dec. 8 7 5			+13·2	−0·6	−12·6	0·0	−1·6	+1·3	−0·3
12 9 55			+ 4·7	−0·4	− 4·5	−0·2	−4·4	+5·5	+1·1
25 20 15			+ 6·2	−0·6	− 7·2	−1·6	+1·8	−0·2	+1·6

Errors of Hansen's Tables deduced

Approx. G.M.T. 1854.			Longitude.				E.N.P.D.		
			B−O	Corr. to B.	H−B	H−O	B−O	H−B	H−O
	d h m		"	"	"	"	"	"	"
Jan.	5	5 45	+ 4·8	−0·4	− 7·4	−3·0	−0·4	+1·2	+0·8
	8	7 53	+ 7·6	−0·4	− 9·6	−2·4	−8·3	+6·3	−2·0
	19	16 35	+ 8·7	−0·6	− 6·9	+1·2	−1·6	+3·3	+1·7
	20	17 20	+ 8 8	−0·6	− 8·3	−0·1	−1·4	+2·7	+1·3
	21	18 8	+ 5·9	−0·5	− 9·5	−4·1	−0·2	+1·7	+1·5
	22	18 58	+ 7·5	−0·6	− 9·1	−2·2	−0·1	0·0	−0·1
Feb.	2	4 21	+ 4·4	−0·5	− 4·6	−0·7	+1·2	−1·2	0·0
	3	5 5	+ 6·1	−0·5	− 6·2	−0·6	−2·0	+0·5	−1·5
	7	8 7	+ 4·8	−0·4	− 8·2	−3·8	−6·8	+6·2	−0·6
	9	9 47	+ 1·3	−0·3	− 1·8	−0·8	−7·0	+5·9	−1·1
	11	11 28	− 0·3	−0·3	+ 0·5	−0·1	−5·2	+4·6	−0·6
	12	12 16	− 0·6	−0·3	− 1·6	−2·5	−4·7	+4·2	−0·5
	13	13 3	+ 2·8	−0·4	− 4·3	−1·9	−2·1	+3·6	+1·5
	17	16 5	+11·7	−0·7	−11·9	−0·9	−0·6	+0·8	+0·2
	18	16 54	+12·0	−0·7	−13·7	−2·4	+1·4	−0·8	+0·6
Mar.	2	2 56	+ 2·9	−0·5	− 5·3	−2·9	+5·7	−0·8	+4·9
	3	3 41	+ 6·2	−0·5	− 7·0	−1·3	−0·1	+0·8	+0·7
	5	5 12	+ 4·8	−0·4	− 7·8	−3·4	−4·1	+3·6	−0·5
	6	5 59	+ 5·3	−0·4	− 8·2	−3·3	−5·0	+4·7	−0·3
	9	8 30	− 0·5	−0·3	− 4·7	−5·5	−7·1	+5·5	−1·6
	10	9 20	− 2·8	−0·2	− 1·6	−4·6	−6·1	+5·0	−1·1
	11	10 9	− 3·8	−0·2	+ 0·7	−3·3	−3·4	+4·2	+0·8
	12	10 57	− 3·7	−0·2	+ 1·3	−2·6	−5·2	+3·8	−1·4
	13	11 43	− 2·9	−0·3	− 0·3	−3·5	−4·9	+3·0	−1·9
	16	14 2	+ 9·0	−0·6	−10·3	−1·9	+2·2	−0·9	+1·3
	17	14 51	+12·8	−0·7	−13·4	−1·3	+5·7	−2·8	+2·9
	19	16 39	+14·7	−0·9	−16·5	−2·7	+8·7	−7·1	+1·6
Apr.	1	3 4	+ 3·9	−0·4	− 7·1	−3·6	−3·1	+4·6	+1·5
	4	5 30	+ 3·2	−0·4	− 6·6	−3·8	−6·1	+6·2	+0·1
	5	6 21	+ 3·3	−0·4	− 6·7	−3·8	−6·7	+6·1	−0·6
	6	7 11	+ 1·9	−0·4	− 6·1	−4·6	−7·8	+6·0	−1·8
	7	8 0	+ 2·1	−0·4	− 4·6	−2·9	−6·5	+5·6	−0·9
	8	8 48	− 0·7	−0·3	− 2·6	−3·6	−6·0	+5·1	−0·9
	9	9 35	− 4·1	−0·2	− 1·1	−5·4	−4·2	+4·7	+0·5
	10	10 21	− 0·8	−0·3	− 0·9	−2·0	−1·5	+4·0	+2·5
	11	11 7	− 1·3	−0·3	− 2·9	−4·5	−1·8	+3·1	+1·3
	13	12 43	+ 9·2	−0·6	−10·6	−2·0	+1·1	−0·2	+0·9
	14	13 35	+10·6	−0·7	−14·4	−4·5	+4·7	−2·2	+2·5
	15	14 31	+15·1	−0·9	−16·6	−2·4	+7·6	−4·8	+2·8
	17	16 33	+15·7	−1·0	−16·5	−1·8	+8·2	−8·1	+0·1

Approx. G.M.T. 1854.			Longitude.				R.N.P.D.		
d	h	m	B−O	Corr. to B.	H−B	H−O	B−O	H÷B	H−O
Apr. 18	17	35	+18·3	−1·2	−15·2	+1·9	+10·2	−8·1	+2·1
May 4	5	52	+ 1·8	−0·4	− 6·7	−5·3	− 5·7	+4·0	−1·7
5	6	40	+ 2·3	−0·4	− 7·1	−5·2	− 6·8	+3·6	−3·2
6	7	26	+ 1·8	−0·4	− 6·9	−5·5	− 5·7	+3·6	−2·1
7	8	12	− 2·9	−0·2	− 6·6	−9·7	− 4·4	+3·3	−1·1
8	8	57	+ 3·0	−0·4	− 6·8	−4·2	− 3·2	+3·1	−0·1
10	10	30	+ 6·1	−0·5	− 9·4	−3·8	− 3·3	+2·1	−1·2
11	11	22	+ 6·0	−0·5	−12·8	−7·3	+ 0·1	+1·0	+1·1
12	12	17	+13·3	−0·8	−16·3	−3·8	+ 1·8	−0·5	+1·3
15	15	25	+19·1	−1·2	−18·2	−0·3	+ 4·1	−3·8	+0·3
18	18	21	+13·1	−0·9	− 9·0	+3·2	+ 5·7	−0·8	+4·9
19	19	11	+ 7·2	−0·5	− 6·3	+0·4	− 2·3	+1·3	−1·0
June 1	4	35	+ 5·0	−0·4	− 8·9	−4·3	− 0·1	+0·3	+0·2
3	6	5	+ 3·1	−0·3	− 9·5	−6·7	+ 0·5	−0·6	−0·1
8	10	0	+ 5·7	−0·5	−13·3	−8·1	+ 3·2	−3·0	+0·2
10	12	0	+11·2	−0·8	−16·7	−6·3	+ 3·7	−4·6	−0·9
12	14	12	+18·8	−1·2	−18·8	−1·2	+ 7·5	−4·2	+3·3
17	18	41	+ 5·3	−0·4	− 3·6	+1·3	− 4·3	+3·9	−0·4
July 6	8	40	+10·2	−0·6	−14·8	−5·2	+ 5·9	−6·5	−0·6
12	14	56	+21·6	−1·2	−15·2	+5·2	+ 2·7	−5·8	−3·1
13	15	50	+13·7	−0·9	−11·7	+1·1	+ 4·0	−4·1	−0·1
17	18	50	+ 6·5	−0·5	− 3·4	+2·6	− 2·9	+3·9	+1·0
18	19	35	+ 2·5	−0·3	− 1·6	+0·6	− 6·8	+5·2	−1·6
Aug. 6	10	34	+13·1	−1·0	−17·4	−5·3	+ 8·3	−6·9	+1·4
8	12	38	+20·6	−1·2	−21·1	−1·7	+ 6·0	−6·8	−0·8
10	14	25	+21·5	−1·2	−19·6	+0·7	+ 4·2	−5·2	−1·0
11	15	13	+16·8	−1·0	−16·4	−0·6	+ 3·6	−4·1	−0·5
12	15	59	+15·8	−0·9	−12·1	+2·8	+ 2·0	−2·5	−0·5
13	16	45	+12·1	−0·7	− 8·3	+3·1	− 0·1	−0·9	−1·0
14	17	30	+ 7·8	−0·5	− 5·9	+1·4	− 2·2	+0·6	−1·6
29	4	25	+12·6	−0·8	−19·8	−8·0	− 5·2	+2·9	−2·3
Sept. 1	7	14	+11·2	−0·8	−19·1	−8·7	+ 2·7	−1·0	+1·7
2	8	17	+14·9	−1·0	−19·7	−5·8	+ 0·7	−1·5	−0·8
3	9	21	+15·3	−1·0	−20·3	−6·0	+ 0·6	−1·4	−0·8
4	10	21	+20·5	−1·2	−22·0	−2·7	0·0	−1·2	−1·2
5	11	19	+22·9	−1·3	−23·6	−2·0	+ 1·4	−0·8	+0·6
6	12	12	+26·5	−1·4	−25·5	−0·4	+ 3·6	−0·6	+3·0
9	14	35	+21·0	−1·0	−18·5	+1·5	− 1·0	+0·7	−0·3
10	15	22	+14·7	−0·8	−12·7	+1·2	+ 1·2	+1·2	+2·4
11	16	9	+11·9	−0·7	− 7·7	+3·5	− 0·5	+1·7	+1·2

Errors of Hansen's Tables deduced

Approx. G.M.T. 1854			Longitude.				R.N.P.D.		
			B−O	Corr. to B.	H−B	H−O	B−O	H−B	H−O
	d	h	m							

	d h m	B−O	Corr. to B.	H−B	H−O	B−O	H−B	H−O
Sept. 28	5 7	+ 1″6	−0″4	−14″4	−13″2	−4″2	−0″4	−4″6
29	6 9	+ 3·2	−·05	−14·2	−11·5	−0·2	−0·8	−1·0
30	7 11	+ 7·7	−·07	−15·2	− 8·2	+0·6	−0·9	−0·3
Oct. 1	8 11	+10·2	−0·8	−16·5	− 7·1	−0·9	−0·2	−1·1
2	9 7	+14·0	−0·9	−18·0	− 4·9	+0·5	+0·9	+1·4
3	10 1	+15·1	−0·9	−19·6	− 5·4	−1·2	+2·0	+0·8
4	10 50	+15·7	−1·0	−20·7	− 6·0	+1·1	+3·1	+4·2
7	13 12	+16·6	−0·8	−17·6	− 1·8	−6·1	+4·4	−1·7
8	13 59	+15·5	−0·8	−13·2	+ 1·5	−5·2	+4·3	−0·9
9	14 48	+10·5	−0·6	− 8·0	+ 1·9	−7·0	+3·7	−3·3
11	16 29	+ 2·6	−0·4	+ 0·2	+ 2·4	−3·6	+2·7	−0·9
12	17 20	− 2·8	−0·2	+ 0·7	− 2·3	−1·7	+2·5	+0·8
28	6 5	+ 9·1	−0·7	−14·6	− 6·2	+2·1	−2·5	−0·4
29	7 2	+11·2	−0·8	−14·2	− 3·8	+1·4	−1·9	−0·5
30	7 55	+15·0	−0·9	−14·4	− 0·3	+1·3	−0·5	+0·8
31	8 45	+12·0	−0·8	−14·9	− 3·7	−0·4	+0·8	+0·4
Nov. 2	10 18	+10·1	−0·6	−13·2	− 3·7	−4·5	+3·7	−0·8
3	11 4	+12·3	−0·7	−12·1	− 0·5	−3·6	+4·0	+0·4
5	12 38	+11·6	−0·6	−10·0	+ 1·0	−4·4	+4·1	−0·3
6	13 28	+ 7·8	−0·5	− 8·0	− 0·7	−2·7	+3·3	+0·6
9	16 2	+ 1·1	−0·3	+ 1·1	+ 1·9	+2·8	+0·4	+3·2
29	8 15	+12·1	−0·7	−13·5	− 2·1	−1·2	+3·3	+2·1
Dec. 1	9 45	+ 4·4	−0·4	− 7·5	− 3·5	−4·0	+5·0	+1·0
2	10 32	+ 8·8	−0·6	− 5·7	+ 2·5	−4·2	+5·1	+0·9
3	11 21	+ 3·8	−0·4	− 5·3	− 1·9	−5·8	+4·6	−1·2
5	13 3	+ 6·7	−0·5	− 6·7	− 0·5	−1·9	+2·0	+0·1
6	13 55	+ 9·6	−0·6	− 5·7	+ 3·3	−1·0	+0·5	−0·5
7	14 45	+ 6·0	−0·5	− 3·6	+ 1·9	+0·6	−0·8	−0·2
8	15 34	+ 4·7	−0·4	− 1·2	+ 3·1	+4·0	−1·6	+2·4
9	16 20	+ 0·7	−0·3	+ 0·2	+ 0·6	+0·9	−1·8	−0·9
10	17 4	+ 0·2	−0·2	− 0·4	− 0·4	+2·9	−1·8	+1·1
11	17 47	+ 2·7	−0·3	− 2·9	− 0·5	+1·3	−1·6	−0·3
12	18 29	+ 5·8	−0·4	− 6·1	− 0·7	+2·7	−1·4	+1·3
14	19 54	+ 9·7	−0·6	− 9·3	− 0·2	+0·2	−1·3	−1·1
25	5 28	+ 9·7	−0·6	−12·4	− 3·3	−2·8	+2·4	−0·4
26	6 14	+10·5	−0·6	−11·9	− 2·0	−3·8	+3·7	−0·1
27	6 59	+ 8·7	−0·5	−11·7	− 3·5	−4·8	+5·0	+0·2
28	7 44	+ 8·2	−0·5	−10·0	− 2·3	−5·2	+6·5	+1·3
29	8 30	+ 2·7	−0·3	− 6·8	− 4·4	−7·8	+7·0	−0·8
30	9 17	+ 2·8	−0·3	− 3·5	− 1·0	−7·9	+6·9	−1·0
31	10 6	− 2·5	−0·1	− 1·5	− 4·1	−5·6	+6·2	+0·6

Approx. G.M.T. 1855.			Longitude.				E.N.P.D.		
			B−0	Corr. to B.	H−B	H−0	B−0	H−B	H−0
	d	h	m						
Jan. 3	12	40	+ 5˝·1	−0˝·5	− 4˝·7	−0˝·1	−3˝·8	+2˝·4	−1˝·4
4	13	29	+ 6·2	−0·5	− 5·3	+0·4	−2·6	+0·9	−1·7
27	8	3	+ 4·8	−0·4	− 5·5	−1·1	−5·7	+6·4	+0·7
Feb. 3	13	42	+ 5·4	−0·4	− 3·3	+1·7	+1·8	+1·0	+2·8
9	18	1	+ 4·5	−0·4	− 9·0	−4·9	+1·5	−1·1	+0·4
20	3	33	+ 7·0	−0·5	− 9·7	−3·2	−2·0	+1·9	−0·1
22	5	8	+ 3·5	−0·4	− 6·0	−2·9	−5·2	+3·1	−2·1
23	5	58	+ 5·3	−0·4	− 6·5	−1·6	−2·7	+3·5	+0·8
Mar. 1	10	57	− 5·1	−0·1	+ 3·2	−2·0	+0·4	−0·9	−0·5
2	11	41	− 5·5	−0·1	+ 3·8	−1·8	+1·5	−1·0	+0·5
3	12	23	− 2·0	−0·2	+ 1·6	−0·6	0·0	−0·8	−0·8
4	13	4	+ 4·3	−0·4	− 2·8	+1·1	+1·9	−1·0	+0·9
5	13	45	+ 5·8	−0·4	− 6·7	−1·3	+4·0	−1·0	+3·0
6	14	27	+11·7	−0·6	− 9·4	+1·7	+3·8	−1·7	+2·1
8	15	57	+11·2	−0·6	−10·8	−0·2	+4·2	−2·9	+1·3
25	6	24	+10·2	−0·6	−10·5	−0·9	−3·6	+3·1	−0·5
26	7	16	+12·2	−0·7	−11·9	−0·4	−4·0	+1·8	−2·2
30	10	20	− 1·2	−0·2	− 1·8	−3·2	+1·5	−2·3	−0·8
31	11	2	− 2·5	−0·2	− 0·4	−3·1	+2·5	−2·2	+0·3
Apr. 1	11	43	− 2·6	−0·2	− 1·5	−4·3	+3·1	−2·5	+0·6
4	13	55	+10·0	−0·5	− 9·9	−0·4	+5·7	−3·9	+1·8
7	16	37	+11·6	−0·8	−14·6	−3·8	+3·7	−6·4	−2·7
22	5	7	+ 7·6	−0·5	− 8·8	−1·7	−3·8	+3·3	−0·5
23	5	58	+ 6·8	−0·5	−10·1	−3·8	−2·1	+1·6	−0·5
25	7	32	+10·1	−0·6	−12·2	−2·7	−0·6	−1·0	−1·6
27	8	57	+ 3·6	−0·4	− 9·4	−6·2	−2·5	−2·3	−4·8
May 1	11	49	+ 5·4	−0·5	− 6·2	−1·3	+2·0	−1·9	+0·1
2	12	38	+ 7·6	−0·5	− 7·9	−0·8	+3·7	−1·9	+1·8
4	14	31	+11·7	−0·8	−12·0	−1·1	+5·5	−2·7	+2·8
5	15	32	+15·8	−1·0	−14·7	+0·1	+4·6	−2·7	+1·9
8	18	30	+16·3	−0·9	−14·1	+1·3	+0·6	+0·2	+0·8
23	6	10	+ 5·8	−0·4	− 9·1	−3·7	+2·6	−2·4	+0·2
25	7	33	+ 9·0	−0·5	−10·4	−1·9	+2·8	−4·1	−1·3
26	8	14	+ 8·6	−0·4	− 9·8	−1·6	+6·0	−4·2	+1·8
June 1	13	20	+11·4	−0·8	−13·2	−2·6	+2·8	−1·9	+0·9
2	14	24	+17·0	−1·0	−15·7	+0·3	+2·9	−0·8	+2·1

Errors of Hansen's Tables deduced

Approx. G.M.T. 1855.			Longitude.				E.N.P.D.		
			B−O	Corr. to B.	H−B	H−O	B−O	H−B	H−O
d	h	m							
June 5	17	20	+ 14·9	−0·8	− 13·0	+ 1·1	− 2·0	+ 2·7	+ 0·7
9	20	32	− 1·7	−0·1	− 1·0	−2·8	−10·1	+ 9·2	− 0·9
20	4	48	+ 5·8	−0·4	− 7·6	−2·2	+ 1·3	−2·0	− 0·7
21	5	28	+ 4·5	−0·4	− 8·3	−4·2	+ 1·8	−2·9	− 1·1
24	7	32	+ 7·4	−0·4	− 10·1	−3·1	+ 7·6	−6·5	+ 1·1
26	9	7	+ 4·7	−0·4	− 8·9	−4·6	+ 6·2	−7·9	− 1·7
27	10	2	+ 4·4	−0·4	− 9·3	−5·3	+ 7·9	−7·8	+ 0·1
28	11	2	+ 9·6	−0·7	− 11·5	−2·6	+ 8·8	−7·3	+ 1·5
30	13	12	+ 18·4	−1·2	− 17·7	−0·5	+ 4·1	−4·4	− 0·3
July 4	16	57	+ 12·2	−0·7	− 9·4	+ 2·1	− 0·6	+ 2·1	+ 1·5
25	8	43	+ 11·9	−0·8	− 14·6	−3·5	+ 8·9	−8·5	+ 0·5
26	9	45	(+ 12·2)	−0·9	− 15·7	(−4·4)	(− 3·2)	−8·9	(−12·1)
27	10	50	+ 17·8	−1·2	− 17·3	−0·7	+ 8·0	−8·2	− 0·2
28	11	55	+ 19·8	−1·3	− 19·3	−0·8	+ 7·4	−7·1	+ 0·3
31	14	48	+ 18·4	−1·1	− 15·3	+ 2·0	+ 2·0	−2·9	− 0·9
Aug. 2	16	26	+ 8·2	−0·7	− 7·2	+0·3	+ 3·2	+0·4	+ 3·6
4	18	3	+ 8·4	−0·6	− 2·9	+4·9	− 4·1	+3·9	− 0·2
18	4	5	+ 15·7	−0·8	− 17·6	−2·7	− 0·5	+0·8	+ 0·3
21	6	30	+ 16·0	−0·9	− 19·3	−4·2	+ 4·7	−3·1	+ 1·6
25	10	37	+ 18·3	−1·2	− 20·5	−3·4	+ 3·6	−2·9	+ 0·7
26	11	37	+ 20·4	−1·3	− 21·0	−1·9	+ 2·7	−2·0	+ 0·7
27	12	33	+ 22·5	−1·2	− 21·1	+0·2	+ 1·1	−0·9	+ 0·2
28	13	26	+ 24·6	−1·3	− 20·0	+3·3	− 0·7	0·0	− 0·7
29	14	16	+ 19·2	−1·1	− 16·5	+1·6	0·0	+1·0	+ 1·0
30	15	6	+ 12·8	−0·8	− 11·7	+0·3	− 4·5	+1·8	− 2 7
Sept. 1	16	47	+ 8·0	−0·6	− 4·7	+2·7	− 3·2	+3·6	+ 0·4
2	17	39	+ 7·1	−0·6	− 3·7	+2·8	− 4·5	+3·7	− 0·8
6	21	9	+ 10·5	−0·6	− 6·3	+3·6	+ 1·3	+0·7	+ 2·0
20	7	19	+ 14·9	−1·0	− 19·4	−5·5	− 1·2	0·0	− 1·2
21	8	20	+ 13·6	−1·0	− 18·7	−6·1	+ 0·1	+0·7	+ 0·8
22	9	19	+ 12·1	−0·9	− 16·9	−5·7	+ 0·2	+1·9	+ 2·1
23	10	16	+ 13·2	−0 9	− 16·0	−3·6	− 3·3	+2·8	− 0·5
24	11	10	+ 14·7	−0·9	− 16·4	−2·6	− 2·9	+3·8	+ 0·9
25	12	1	+ 18·0	−0·9	− 17·8	−0·7	− 4·4	+5·0	+ 0·6
26	12	52	+ 19·9	−1·0	− 18·0	+0·9	− 5·5	+5·8	+ 0·3
Oct. 5	20	39	+ 11·2	−0·6	− 7·8	+2·8	+ 1·0	−0·5	+ 0·5
18	6	10	+ 5·1	−0·5	− 12·4	−7·8	− 2·0	−0·1	− 2·1
19	7	9	+ 8·5	−0·7	− 12·3	−4·5	− 0·8	+0·2	− 0·6
24	11	28	+ 9·5	−1·3	− 10·7	−2·5	− 6·1	+6·6	+ 0·5
26	13	13	+ 14·3	−0·8	− 11·0	+2·5	− 6·6	+7·0	+ 0·4
31	17	47	+ 5·4	−0·5	− 5·3	−0·4	+ 0·1	+0·8	+ 0·9

Approx. G.M.T. 1855.			Longitude.				E.N.P.D.		
			B−O	Corr. to B.	H−B	H−O	B−O	H−B	H−O
d	h	m							
Nov. 3	20	0	+ 8″8	−0″5	− 6″8	+1″5	+ 0″5	−1″3	−0″8
15	5	4	+ 9·0	−0·7	−11·2	−2·9	− 0·7	−0·3	−1·0
16	5	59	+ 7·8	−0·6	−10·0	−2·8	− 1·8	−0·5	−2·3
20	9	18	(+ 1·1)	−0·3	− 9·0	(−8·2)	(− 6·2)	+4·4	(−1·8)
22	10	59	+ 5·6	−0·4	− 6·5	−1·3	− 7·0	+6·0	−1·0
25	13	47	+ 9·0	−0·7	− 7·7	+0·6	− 4·3	+3·9	−0·4
26	14	43	+ 9·6	−0·7	− 7·5	+1·4	− 1·7	+2·4	+0·7
29	17	12	+ 0·7	−0·3	− 3·4	−3·0	+ 1·6	−1·2	+0·4
Dec. 2	19	15	+ 5·7	−0·4	− 5·5	−0·2	+ 2·9	−2·7	+0·2
18	8	2	+ 9·6	−0·6	−12·0	−3·0	− 5·4	+5·5	+0·1
19	8	51	+10·1	−0·6	−10·0	−0·5	− 6·2	+6·6	+0·4
20	9	43	+ 5·3	−0·4	− 7·2	−2·3	−10·5	+7·2	−3·3
21	10	38	+ 1·0	−0·3	− 5·2	−4·5	− 2·3	+6·8	+4·5
24	13	26	+ 7·8	−0·6	− 6·0	+1·2	− 4·9	+3·2	−1·7
26	15	5	+ 3·2	−0·4	− 4·1	−1·3	+ 1·0	+0·8	+1·8
27	15	49	+ 2·7	−0·4	− 2·7	−0·4	− 2·2	−0·2	−2·4
29	17	11	+ 4·2	−0·3	− 3·3	+0·6	− 4·5	−1·1	−5·6
30	17	50	− 1·0	−0·2	− 4·7	−5·9	+ 3·0	−1·7	+1·3

Errors of Hansen's Tables deduced

Approx. G.M.T. 1856.			Longitude.				R.N.P.D.		
			B−O	Corr. to B.	H−B	H−O	B−O	H−B	H−O
	d	h m							
Jan. 12	4	24	+ 10·8	−0·6	− 15·4	− 5·2	− 3·8	+ 3·0	− 0·8
13	5	12	+ 9·5	−0·6	− 12·0	− 3·1	− 4·6	+ 4·2	− 0·4
14	6	0	+ 10·4	−0·6	− 10·8	− 1·0	− 6·5	+ 5·6	− 0·9
15	6	48	+ 8·5	−0·5	− 10·9	− 2·9	− 8·3	+ 6·9	− 1·4
18	9	27	+ 1·9	−0·3	− 5·4	− 3·8	− 6·8	+ 6·6	− 0·2
19	10	22	+ 0·5	−0·3	− 2·7	− 2·5	− 6·7	+ 5·2	− 1·5
24	14	27	+ 3·9	−0·4	− 3·3	+ 0·2	+ 1·4	+ 0·9	+ 2·3
25	15	7	+ 3·2	−0·3	− 2·6	+ 0·3	+ 1·1	+ 0·4	+ 1·5
27	16	25	+ 1·2	−0·3	− 2·9	− 2·0	+ 2·4	− 0·5	+ 1·9
28	17	5	+ 3·5	−0·3	− 4·1	− 0·9	+ 3·0	− 1·4	+ 1·6
29	17	48	+ 4·2	−0·4	− 5·4	− 1·6	+ 3·4	− 2·5	+ 0·9
Feb. 14	7	22	+ 8·2	−0·6	− 9·2	− 1·6	− 5·6	+ 5·5	− 0·1
15	8	18	+ 6·1	−0·5	− 7·6	− 2·0	− 3·1	+ 4·0	+ 0·9
16	9	13	+ 4·1	−0·4	− 4·5	− 0·8	− 3·2	+ 2·2	− 1·0
24	15	3	+ 4·7	−0·4	− 5·2	− 0·9	+ 3·7	− 1·3	+ 2·4
25	15	44	+ 2·5	−0·3	− 4·9	− 2·7	+ 3·2	− 1·9	+ 1·3
26	16	28	+ 3·0	−0·3	− 4·7	− 2·0	+ 3·4	− 2·7	+ 0·7
Mar. 13	6	12	+ 4·7	−0·5	− 9·1	− 4·9	− 4·5	+ 4·1	− 0·4
14	7	8	+ 7·9	−0·6	− 9·6	− 2·3	− 1·9	+ 2·1	+ 0·2
22	13	3	+ 4·6	−0·3	− 6·0	− 1·7	+ 4·0	− 3·6	+ 0·4
26	16	1	+ 3·0	−0·3	− 8·7	− 6·0	+ 6·9	− 4·2	+ 2·7
28	17	52	+ 6·1	−0·5	− 5·9	− 0·3	+ 3·8	− 4·2	− 0·4
29	18	51	+ 2·9	−0·4	− 3·1	− 0·6	+ 3·3	− 3·7	− 0·4
Apr. 9	4	0	+ 4·9	−0·5	− 9·2	− 4·8	− 2·8	+ 6·2	+ 3·4
12	6	48	+ 8·5	−0·6	− 9·8	− 1·9	− 0·7	+ 0·2	− 0·5
13	7	37	+ 10·0	−0·6	− 12·0	− 2·6	+ 0·7	− 1·9	− 1·2
15	9	4	+ 10·5	−0·6	− 11·8	− 1·9	+ 2·1	− 4·8	− 2·7
16	9	44	+ 3·0	−0·3	− 9·3	− 6·6	+ 5·2	− 5·2	0·0
20	12	24	+ 2·3	−0·3	− 5·4	− 3·4	+ 5·3	− 3·8	+ 1·5
21	13	9	+ 3·6	−0·3	− 7·9	− 4·6	+ 5·7	− 3·5	+ 2·2
22	13	58	+ 8·6	−0·5	− 10·2	− 2·1	+ 4·4	− 3·1	+ 1·3
27	18	38	+ 5·9	−0·5	− 8·9	− 3·5	+ 0·2	− 0·9	− 0·7
May 10	5	30	+ 6·4	−0·5	− 7·2	− 1·3	− 3·0	+ 1·5	− 1·5
11	6	17	+ 6·4	−0·5	− 9·9	− 4·0	+ 0·2	− 0·4	− 0·2
13	7	42	+ 11·9	−0·6	− 14·9	− 3·6	+ 3·7	− 4·1	− 0·4
14	8	21	+ 11·8	−0·5	− 14·5	− 3·2	+ 5·8	− 5·0	+ 0·8

Approx. G.M.T. 1856.		Longitude.				R.N.P.D.		
d h m	B–O	Corr. to B.	H–B	H–O		B–O	H–B	H–O
May 17 10 21	+ 2·9	–0·3	– 4·2	– 1·6		+ 5·5	–4·9	+0·6
18 11 5	+ 0·2	–0·2	– 3·0	–3·0		+ 2·9	–4·1	–1·2
19 11 53	+ 1·2	–0·3	– 3·6	–2·7		+ 3·5	–3·1	+0·4
20 12 45	+ 6·1	–0·5	– 6·0	–0·4		+ 2·5	–2·3	+0·2
22 14 39	+ 6·7	–0·6	–10·5	–4·4		– 0·6	–0·3	–0·9
26 18 19 ·	+14·9	–0·8	–14·2	–0·1		– 2·4	+4·0	+1·6
June 10 6 18	+ 7·2	–0·4	–10·9	–4·1		+ 4·3	–2·4	+1·9
11 6 57	+ 7·7	–0·4	–11·3	–4·0		+ 6·0	–4·0	+2·0
14 8 59	+ 3·2	–0·3	– 5·7	–2·8		+ 6·4	–6·9	–0·5
15 9 46	+ 0·5	–0·2	– 4·3	–4·0		+ 7·5	–6·5	+1·0
17 11 32	+ 4·6	–0·5	– 6·4	–2·3		– 0·6	–5·0	–5·6
20 14 28	+12·2	–0·8	–11·9	–0·5		+ 1·0	– 1·2	–0·2
25 18 41	+12·0	–0·6	– 9·0	+2·4		– 5·8	+7·5	+1·7
26 19 30	+ 9·4	–0·5	– 4·4	+4·5		–11·5	+9·2	–2·3
July 16 11 16	+13·7	–0·9	–13·5	–0·7		+ 5·3	–6·8	–1·5
17 12 16	+16·2	–1·1	–15·5	–0·4		+ 8·0	–6·0	+2·0
18 13 15	+18·5	–1·1	–16·5	+0·9		+ 5·1	–4·7	+0·4
22 16 39	+13·8	–0·8	–10·6	+2·4		– 1·2	+3·0	+1·8
25 19 11	+ 8·3	–0·5	– 6·2	+1·6		– 7·6	+7·0	–0·6
Aug. 5 3 28	+10·7	–0·6	–13·3	–3·2		– 1·7	+1·0	–0·7
6 4 7	+ 4·5	–0·4	– 9·2	–5·1		– 1·3	+0·6	–0·7
7 4 47	+ 4·0	–0·4	– 6·9	–3·3		+ 2·7	–0·1	+2·6
10 7 7	+ 6·0	–0·5	– 9·8	–4·3		+ 4·7	–3·7	+1·0
12 9 0	+ 9·5	–0·7	–14·2	–5·4		+ 4·9	–5·2	–0·3
13 10 0	+11·3	–0·8	–15·8	–5·3		+ 5·1	–5·3	–0·2
14 10 59	+14·8	–1·0	–17·1	–3·3		+ 4·9	–4·9	0·0
15 11 56	+18·8	–1·1	–18·7	–1·0		+ 4·2	–4·1	+0·1
22 18 2	+12·7	–0·8	– 7·4	+4·5		– 7·0	+5·5	–1·5
Sept. 12 10 35	+11·9	–0·8	–13·8	–2·7		+ 1·5	–0·5	+1·0
14 12 20	+15·2	–0·9	–15·2	–0·9		– 1·4	+1·8	+0·4
15 13 11	+16·8	–0·9	–15·0	+0·9		– 3·7	+3·7	0·0
16 14 3	+16·7	–0·9	–12·9	+2·9		– 4·9	+4·8	–0·1
18 15 54	+13·3	–0·8	–10·7	+1·8		– 6·3	+6·3	0·0
19 16 53	+18·5	–1·1	–11·4	+6·0		– 5·7	+5·8	+0·1
21 18 50	+17·5	–1·0	–11·5	+5·0		– 2·6	+3·2	+0·6
23 20 35	+12·6	–0·7	– 8·4	+3·5		+ 0·8	+0·4	+1·2

Errors of Hansen's Tables deduced

Approx. G.M.T. 1856.			Longitude.				E.N.P.D.		
			B−O	Corr. to B.	H−B	H−O	B−O	H−B	H−O
d	h	m							
Oct. 12	10	55	+ 3·4	−0·4	− 7·8	−4·8	−4·5	+3·9	−0·6
13	11	47	+ 7·9	−0·6	− 8·9	−1·6	−5·2	+5·6	+0·4
16	14	38	+16·4	−1·0	−13·3	+2·1	−7·6	+6·3	−1·3
21	19	20	+19·0	−0·9	−10·9	+7·2	−1·0	−0·5	−1·5
Nov. 4	5	17	+ 5·9	−0·5	−11·6	−6·2	−0·9	+0·7	−0·2
6	7	2	+ 8·9	−0·6	−11·4	−3·1	+0·6	+0·6	+1·2
8	8	41	+ 4·8	−0·5	− 9·5	−5·2	−0·9	+2·4	+1·5
10	10	23	+ 1·9	−0·3	− 5·7	−4·1	−6·5	+4·9	−1·6
11	11	19	+ 4·2	−0·4	− 6·8	−3·0	−6·3	+6·1	−0·2
14	14	23	+14·0	−0·9	−11·7	+1·4	−4·9	+4·9	0·0
15	15	25	+12·6	−0·9	−11·2	+0·5	−1·7	+3·5	+1·8
16	16	22	+15·3	−0·9	−10·6	+3·8	+0·1	+1·9	+2·0
Dec. 2	4	7	+ 9·4	−0·6	−13·5	−4·7	0·0	−1·4	−1·4
7	8	11	+ 9·0	−0·6	−12·5	−4·1	−5·3	+3·2	−2·1
9	9	59	+ 5·8	−0·5	−10·1	−4·8	−7·2	+5·5	−1·7
13	14	6	+11·9	−0·8	− 9·9	+1·2	−3·7	+4·2	+0·5
14	15	2	+10·9	−0·7	− 9·3	+0·9	−2·4	+3·3	+0·9
15	15	52	+ 8·5	−0·6	− 8·9	−1·0	−2·5	+2·1	−0·4
16	16	38	+11·4	−0·7	− 8·5	+2·2	−0·1	+0·8	+0·7
17	17	20	+10·9	−0·6	− 8·2	+2·1	+1·4	−0·5	+0·9
18	18	0	+10·5	−0·5	− 7·9	+2·1	+2·3	−2·0	+0·3

Approx. G.M.T. 1857.			Longitude.				E.N.P.D.		
	d	h m	B−0	Corr. to B.	H−B	H−0	B−0	H−B	H−0
Jan. 2	5	20	+ 8.4	−0.6	−12.3	−4.5	−0.1	−0.2	−0.3
3	6	7	+10.8	−0.7	−12.5	−2.4	−1.2	+1.6	+0.4
11	13	40	+10.2	−0.7	−10.1	−0.6	−2.0	+3.2	+1.2
13	15	13	+ 9.0	−0.6	−10.2	−1.8	−2.6	+2.0	−0.6
14	15	55	+ 9.6	−0.6	− 8.9	+0.1	−1.5	+1.1	−0.4
15	16	34	+ 5.2	−0.4	− 7.6	−2.8	+0.7	+0.1	+0.8
16	17	14	+ 8.4	−0.5	− 6.6	+1.3	+3.2	−0.7	+2.5
31	4	54	+10.0	−0.6	−14.6	−5.2	−5.3	+4.0	−1.3
Feb. 4	8	37	+13.2	−0.9	−16.6	−4.3	−4.4	+3.5	−0.9
7	11	30	+ 7.7	−0.6	− 8.9	−1.8	−0.8	+0.9	+0.1
8	12	20	+ 8.4	−0.6	− 8.6	−0.8	−1.1	+0.9	−0.2
10	13	49	+ 8.8	−0.6	−10.1	−1.9	−1.0	+0.5	−0.5
11	14	29	+ 7.4	−0.5	− 9.2	−2.3	−0.7	+0.1	−0.6
12	15	9	+ 7.3	−0.5	− 7.2	−0.4	−0.9	0.0	−0.9
13	15	49	+ 5.1	−0.4	− 5.4	−0.7	+2.5	−0.4	+2.1
15	17	13	+ 2.2	−0.3	− 5.4	−3.5	+5.6	−1.3	+4.3
16	18	0	+ 1.4	−0.3	− 5.6	−4.5	−0.8	−1.8	−2.6
Mar. 5	8	30	+13.8	−0.9	−15.0	−2.1	−2.6	+0.8	−1.9
6	9	25	+ 8.9	−0.6	−12.7	−4.4	−0.5	−0.9	−1.4
7	10	16	+ 6.6	−0.5	− 9.8	−3.7	−0.2	−1.8	−2.0
8	11	2	+ 6.8	−0.5	− 8.3	−2.0	+2.0	−2.5	−0.5
12	13	45	+ 8.0	−0.5	− 8.3	−0.8	+2.3	−1.8	+0.5
15	15	54	+ 2.9	−0.3	− 5.8	−3.2	+1.9	−1.0	+0.9
16	16	42	+ 1.1	−0.3	− 5.9	−5.1	−2.7	−1.3	−4.0
17	17	33	+ 3.2	−0.4	− 6.0	−3.2	−0.1	−1.6	−1.7
31	5	25	+ 6.2	−0.6	−11.2	−5.6	−2.1	+3.5	+1.4
Apr. 2	7	22	+ 7.9	−0.6	−11.4	−4.1	−1.3	+0.4	−0.9
3	8	13	+10.9	−0.7	−12.1	−1.9	−0.1	−1.3	−1.4
6	10	25	+ 4.2	−0.3	− 8.9	−5.0	+4.9	−4.0	+0.9
8	11	44	+ 2.8	−0.3	− 7.6	−5.1	+2.4	−2.9	−0.5
9	12	24	+ 6.5	−0.4	− 8.4	−2.3	+2.1	−2.2	−0.1
14	16	20	+ 4.6	−0.4	− 9.3	−5.1	−2.1	+0.5	−1.6
18	19	51	+ 1.8	−0.4	− 1.8	−0.4	+2.8	−0.4	+2.4
May 1	6	58	+ 7.4	−0.5	− 8.6	−1.7	−0.1	−0.5	−0.6
3	8	25	+11.1	−0.6	−12.4	−1.9	+2.6	−3.4	−0.8
4	9	5	+ 8.8	−0.5	−11.8	−3.5	+4.9	−4.2	+0.7

Approx. G.M.T. 1857.			Longitude.				E.N.P.D.		
			B−0	Corr. to B.	H−B	H−0	B−0	H−B	H−0
d	h	m	"	"	"	"	"	"	"
May 5	9	44	+ 5·8	−0·4	− 9·6	−4·2	+3·4	−4·1	−0·7
6	10	23	+ 5·3	−0·4	− 7·5	−2·6	+3·8	−3·5	+0·3
7	11	4	+ 2·8	−0·3	− 6·1	−3·6	+3·9	−2·5	+1·4
8	11	48	+ 0·4	−0·2	− 6·4	−6·2	+1·8	−1·5	+0·3
11	14	15	+ 5·3	−0·5	−10·4	−5·6	−2·8	+1·7	−1·1
13	16	2	+10·8	−0·7	−11·7	−1·6	−2·4	+2·7	+0·3
14	16	54	+10·4	−0·6	−12·2	−2·4	−3·9	+2·9	−1·0
17	19	21	+ 8·3	−0·5	− 6·9	+0·9	−5·2	+4·4	−0·8
27	3	58	+ 8·6	−0·7	− 8·6	−0·7	−6·8	+5·2	−1·6
31	7	3	+10·3	−0·5	−11·8	−2·0	+2·0	−2·2	−0·2
June 1	7	43	+ 8·4	−0·4	−12·6	−4·6	+6·3	−3·6	+2·7
2	8	22	+10·5	−0·5	−12·0	−2·0	+3·7	−4·2	−0·5
4	9	45	+ 3·4	−0·3	− 7·2	−4·1	+3·0	−3·2	−0·2
5	10	31	− 1·3	−0·2	− 4·6	−6·1	+1·7	−2·2	−0·5
8	13	4	+ 2·1	−0·3	− 6·5	−4·7	+0·3	+0·6	+0·9
9	13	58	+ 8·3	−0·6	− 8·9	−1·2	−1·7	+1·5	−0·2
10	14	51	+10·6	−0·7	−11·3	−1·4	−1·7	+1·9	+0·2
12	16	30	+14·1	−0·7	−15·0	−1·6	−3·6	+3·6	0·0
13	17	17	+20·3	−0·9	−15·8	+3·6	−5·4	+4·9	−0·5
14	18	3	+19·8	−0·9	−14·5	+4·4	−7·7	+6·3	−1·4
15	18	50	+14·8	−0·7	−10·7	+3·4	−9·0	+7·5	−1·5
25	3	30	+19·5	−0·9	−16·8	+1·8	−3·7	+4·5	+0·8
26	4	17	+14·0	−0·8	−15·1	−1·9	−2·4	+3·1	+0·7
27	4	59	+ 9·0	−0·6	−12·8	−4·4	−1·0	+1·8	+0·8
28	5	40	+ 6·1	−0·4	−11·2	−5·5	+0·4	+0·4	+0·8
29	6	20	+ 7·3	−0·5	−10·2	−3·4	+0·4	−0·8	−0·4
July 6	11	52	+ 4·6	−0·4	− 7·1	−2·9	−2·0	−1·0	−3·0
7	12	46	+ 7·4	−0·6	− 8·8	−2·0	−0·4	−0·6	−1·0
9	14	28	+14·9	−0·8	−12·0	+2·1	+0·9	0·0	+0·9
11	16	2	+18·4	−0·9	−14·0	+3·5	−1·7	+2·4	+0·7
12	16	48	+19·1	−0·9	−14·9	+3·3	−3·1	+3·9	+0·8
31	7	56	+ 3·1	−0·4	− 7·8	−5·1	−1·0	+1·3	+0·3
Aug. 2	9	42	+ 6·0	−0·5	− 9·5	−4·0	+0·2	+0·6	+0·8
3	10	37	+ 4·4	−0·4	−10·8	−6·8	−1·0	−0·1	−1·1
4	11	31	+ 9·2	−0·6	−13·0	−4·4	−2·4	−0·5	−2·9
9	15	32	+14·0	−0·8	−10·5	+2·7	−1·7	+2·4	+0·7
25	4	14	+ 0·7	−0·3	− 7·9	−7·5	+2·0	+1·2	+3·2
29	7	31	− 0·5	−0·2	− 6·2	−6·9	−4·0	+2·8	−1·2
30	8	25	+ 1·9	−0·3	− 7·5	−5·9	−3·2	+2·2	−1·0
31	9	19	+ 6·5	−0·5	− 9·0	−3·0	−3·1	+1·7	−1·4

Approx. G.M.T. 1857.			B—O	Longitude. Corr. to B.	H—B	H—O	H.N.P.D. B—O	H—B	H—O
	d	h m							
Sept. 1	10	11	+ 7.1	−0.5	− 10.8	−4.2	−1.8	+1.3	−0.5
4	12	39	+16.1	−0.9	− 12.9	+2.3	−0.3	+0.9	+0.6
5	13	27	+16.9	−0.9	− 12.1	+3.9	−1.8	+1.6	−0.2
6	14	16	+15.1	−0.8	− 11.3	+3.0	−2.8	+2.5	−0.3
11	19	6	+19.7	−1.2	− 15.5	+3.0	+1.4	+1.1	+2.5
28	7	59	+ 1.1	−0.3	− 6.4	−5.6	−4.5	+3.4	−1.1
29	8	50	+ 3.5	−0.4	− 6.6	−3.5	−2.4	+3.1	+0.7
30	9	39	+ 1.6	−0.3	− 6.3	−5.0	−2.9	+2.9	0.0
Oct. 1	10	27	+ 2.5	−0.3	− 6.5	−4.3	−3.6	+2.8	−0.8
2	11	15	+ 3.4	−0.4	− 7.5	−4.5	−3.3	+3.0	−0.3
6	14	53	+18.5	−1.1	− 15.4	+2.0	−6.0	+3.0	−3.0
8	16	59	+18.6	−1.1	− 16.3	+1.2	−1.2	+1.7	+0.5
9	18	1	+20.8	−1.2	− 17.2	+2.4	+1.2	+0.3	+1.5
25	5	49	+ 4.6	−0.4	− 10.0	−5.8	−6.3	+4.5	−1.8
26	6	39	+ 5.2	−0.4	− 10.1	−5.3	−5.1	+4.2	−0.9
27	7	28	+ 5.5	−0.4	− 10.4	−5.3	−4.3	+4.4	+0.1
29	9	2	+ 3.2	−0.3	− 7.5	−4.6	−7.2	+4.9	−2.3
30	9	50	+ 2.9	−0.4	− 5.9	−3.4	−4.6	+4.6	0.0
31	10	41	+ 6.1	−0.5	− 6.8	−1.2	−5.3	+4.2	−1.1
Nov. 1	11	36	+10.0	−0.7	− 9.5	−0.2	−5.3	+4.0	−1.3
5	15	50	+16.9	−1.1	− 13.2	+2.6	+0.4	−0.2	+0.2
22	4	34	+ 9.5	−0.6	− 16.1	−7.2	−4.2	+2.2	−2.0
24	6	7	+ 9.7	−0.6	− 15.6	−6.5	−1.8	+2.5	+0.7
27	8	26	+14.9	−0.8	− 16.9	−2.8	−2.8	+4.6	+1.8
28	9	17	+12.8	−0.7	− 15.7	−3.6	−5.0	+4.7	−0.3
29	10	14	+10.4	−0.7	− 14.5	−4.8	−6.9	+4.2	−2.7
30	11	15	+10.9	−0.8	− 13.7	−3.6	−5.3	+3.1	−2.2
Dec. 1	12	22	+12.9	−0.9	− 13.4	−1.4	−3.7	+2.3	−1.4
2	13	30	+12.9	−0.9	− 11.8	+0.2	−1.6	+1.5	−0.1
3	14	35	+12.5	−0.9	− 9.9	+1.7	0.0	+0.8	+0.8
4	15	35	+10.8	−0.7	− 8.3	+1.8	+1.3	−0.6	+0.7
7	18	1	+11.1	−0.6	− 8.5	+2.0	+5.1	−5.0	+0.1
10	20	3	+ 7.5	−0.4	− 6.7	+0.4	+7.1	−5.2	+1.9
25	7	6	+14.9	−0.8	− 19.4	−5.3	−1.6	+1.7	+0.1
27	8	55	+15.8	−0.9	− 21.5	−6.6	−3.2	+2.3	−0.9
28	9	57	+15.1	−1.0	− 20.2	−6.1	−3.3	+1.8	−1.5
29	11	4	(+18.8)	−1.2	− 18.3	(−0.7)	(−6.5)	+1.2	(−5.3)
30	12	12	+14.1	−1.0	− 17.3	−4.2	−1.4	+0.7	−0.7
31	13	16	+10.9	−0.8	− 16.7	−6.6	−0.4	+1.0	+0.6

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Approx. G.M.T. 1858.			Longitude.				R.N.P.D.		
			B—O	Corr. to B.	H—B	H—O	B—O	H—B	H—O
	d	h m							
Jan.	1	14 14	+ 15˙2	−0˙9	− 14˙8	−0˙5	+4˙1	+0˙4	+4˙5
	6	18 1	+ 9˙1	−0˙5	− 8˙1	+0˙5	+2˙6	−1˙5	+1˙1
	9	20 12	+ 2˙0	−0˙3	− 6˙7	−5˙0	+0˙6	+0˙4	+1˙0
	19	3 32	+ 8˙0	−0˙6	− 13˙0	−5˙6	+1˙1	−1˙8	−0˙7
	22	5 51	+ 6˙9	−0˙5	− 11˙7	−5˙3	−2˙9	+0˙3	−2˙6
	23	6 44	+ 8˙3	−0˙6	− 15˙0	−7˙3	−1˙9	+0˙7	−1˙2
	24	7 42	+ 11˙1	−0˙8	− 17˙9	−7˙6	−1˙0	+0˙5	−0˙5
	25	8 45	+ 12˙7	−0˙9	− 19˙1	−7˙3	+0˙2	−0˙2	0˙0
	26	9 51	+ 13˙0	−0˙9	− 19˙6	−7˙5	+0˙1	−0˙9	−0˙8
	27	10 55	+ 16˙0	−1˙0	− 19˙7	−4˙7	−0˙1	−1˙4	−1˙5
	28	11 56	+ 16˙4	−1˙0	− 20˙1	−4˙7	+0˙2	−1˙4	−1˙2
	31	14 28	+ 14˙6	−0˙8	− 17˙3	−3˙5	−0˙5	−0˙6	−1˙1
Feb.	1	15 12	+ 14˙0	−0˙7	− 15˙0	−1˙7	+0˙5	−0˙1	+0˙4
	3	16 37	+ 7˙1	−0˙5	− 11˙4	−4˙8	+1˙3	+0˙8	+2˙1
	4	17 20	+ 9˙9	−0˙6	− 11˙0	−1˙7	−1˙0	+1˙6	+0˙6
	6	18 53	+ 4˙5	−0˙5	− 9˙5	−5˙5	−5˙9	+2˙9	−3˙0
	7	19 43	+ 4˙5	−0˙4	− 7˙4	−3˙3	+0˙8	+3˙2	+4˙0
	18	3 48	+ 5˙4	−0˙5	− 11˙5	−6˙6	−2˙7	+1˙7	−1˙0
	19	4 40	+ 6˙1	−0˙5	− 11˙0	−5˙4	−2˙7	+2˙0	−0˙7
	20	5 36	+ 8˙7	−0˙6	− 12˙3	−4˙2	−5˙8	+2˙2	−3˙6
	21	6 36	+ 10˙3	−0˙7	− 15˙0	−5˙4	−2˙1	+1˙5	−0˙6
	22	7 39	+ 9˙9	−0˙8	− 17˙7	−8˙6	−1˙4	+0˙2	−1˙2
	24	9 43	+ 16˙6	−1˙0	− 20˙7	−5˙1	+1˙3	−2˙8	−1˙5
	25	10 39	+ 19˙0	−1˙0	− 20˙2	−2˙2	+3˙3	−3˙3	0˙0
	27	12 18	+ 13˙7	−0˙7	− 16˙0	−3˙0	+3˙2	−3˙4	−0˙2
Mar.	6	17 34	+ 6˙3	−0˙5	− 10˙6	−4˙8	−3˙3	+2˙9	−0˙4
	8	19 17	+ 5˙9	−0˙5	− 7˙5	−2˙1	−7˙8	+2˙7	−5˙1
	21	5 33	+ 8˙0	−0˙7	− 13˙9	−6˙6	−0˙3	+1˙6	+1˙3
	22	6 36	+ 13˙3	−0˙9	− 15˙8	−3˙4	+3˙8	+0˙8	+4˙6
	23	7 36	+ 18˙0	−1˙1	− 19˙1	−2˙2	−1˙4	−0˙7	−2˙1
	24	8 32	+ 19˙6	−1˙0	− 21˙8	−3˙2	+2˙0	−2˙6	−0˙6
	25	9 24	+ 21˙7	−1˙0	− 21˙2	−0˙5	+4˙3	−3˙6	+0˙7
	26	10 12	+ 14˙6	−0˙7	− 18˙0	−4˙1	+4˙6	−4˙4	+0˙2
	29	12 23	+ 7˙3	−0˙5	− 9˙3	−2˙5	+2˙3	−2˙6	−0˙3
Apr.	1	14 37	+ 5˙5	−0˙5	− 8˙3	−3˙3	−2˙3	+2˙1	−0˙2
	3	16 17	+ 4˙9	−0˙4	− 8˙3	−3˙8	−2˙1	+3˙6	+1˙5

Approx. G.M.T. 1858			Longitude.				B.N.P.D.		
			B—O	Corr. to B.	H—B	H—O	B—O	H—B	H—O
d	h	m							
Apr. 18	4	28	+ 7·6	−0·6	−12·2	−5·2	+ 1·1	−0·2	+0·9
19	5	30	+ 8·5	−0·7	−11·0	−3·2	− 1·3	−0·2	−1·5
20	6	29	+10·5	−0·7	−12·1	−2·3	0·0	−1·1	−1·1
21	7	22	+12·2	−0·7	−14·7	−3·2	+ 1·0	−2·4	−1·4
22	8	10	+14·3	−0·7	−16·3	−2·7	+ 4·7	−4·0	+0·7
23	8	55	+13·4	−0·7	−15·4	−2·7	+ 4·7	−4·6	+0·1
24	9	38	+11·7	−0·6	−12·9	−1·8	+ 4·0	−4·6	−0·6
25	10	20	+ 6·0	−0·4	−10·2	−4·6	+ 5·0	−3·7	+1·3
26	11	3	+ 6·4	−0·4	− 8·8	−2·8	+ 6·1	−2·3	+3·8
28	12	32	+ 4·7	−0·4	− 8·5	−4·2	+ 2·4	+1·6	+4·0
May 5	18	19	+ 8·3	−0·5	− 8·3	−0·5	− 4·4	+5·5	+1·1
6	19	4	+ 5·4	−0·4	− 5·9	−0·9	− 6·2	+5·5	−0·7
7	19	48	+ 1·1	−0·2	− 1·6	−0·7	− 6·9	+5·4	−1·5
18	5	17	+ 5·6	−0·5	− 9·9	−4·8	− 1·6	−0·3	−1·9
19	6	8	+ 5·8	−0·5	− 8·7	−3·4	+ 1·2	−1·4	−0·2
22	8	20	+ 6·7	−0·5	− 9·3	−3·1	+ 2·7	−3·6	−0·9
23	9	2	+ 1·6	−0·2	− 8·8	−7·4	+ 7·4	−3·2	+4·2
25	10	29	+ 4·9	−0·4	− 8·1	−3·6	+ 1·8	−0·1	+1·7
30	14	38	+ 3·8	−0·4	− 7·4	−4·0	− 3·4	+5·1	+1·7
June 1	16	14	+ 9·9	−0·5	− 8·5	+0·9	−13·3	+5·5	−7·8
3	17	43	+10·2	−0·5	− 9·4	+0·3	− 7·6	+7·1	−0·5
15	4	0	+12·8	−0·8	−18·8	−6·8	− 2·7	+1·3	−1·4
17	5	35	+ 3·4	−0·4	− 9·8	−6·8	+ 0·7	−0·6	+0·1
18	6	18	+ 5·8	−0·5	− 8·3	−3·0	+ 0·1	−0·9	−0·8
21	8	27	+ 6·9	−0·5	− 8·4	−2·0	+ 1·0	+0·5	+1·5
22	9	13	+ 6·5	−0·5	− 7·9	−1·9	− 2·5	+1·8	−0·7
24	10	52	− 1·9	−0·2	− 5·5	−7·6	− 2·0	+3·5	+1·5
25	11	43	− 0·7	−0·3	− 5·4	−6·4	− 5·2	+3·7	−1·5
27	13	25	+ 5·3	−0·4	− 6·9	−2·0	− 6·2	+3·4	−2·8
28	14	12	+10·5	−0·6	− 8·1	+1·8	− 0·1	+3·2	+3·1
July 1	16	24	+15·4	−0·7	−11·1	+3·6	− 3·5	+4·9	+1·4
15	4	13	+12·5	−0·7	−17·7	−5·9	+ 1·6	−0·8	+0·8
18	6	24	+ 4·3	−0·4	− 9·6	−5·7	− 2·5	+2·1	−0·4
19	7	10	+ 6·8	−0·5	− 9·6	−3·3	− 3·7	+3·3	−0·4
21	8	47	+ 4·6	−0·5	− 7·7	−3·6	− 5·7	+5·0	−0·7
25	12	9	+ 3·9	−0·4	− 5·2	−1·7	− 4·3	+3·7	−0·6
26	12	56	+ 6·9	−0·5	− 6·7	−0·3	− 2·3	+3·0	+0·7
28	14	23	+11·2	−0·6	− 9·0	+1·6	+ 0·1	+2·2	+2·3
30	15	48	+11·5	−0·6	−11·2	−0·3	− 3·7	+2·9	−0·8
31	16	33	+16·5	−0·8	−13·7	+2·0	− 4·0	+3·2	−0·8

Errors of Hansen's Tables deduced

Approx. G.M.T. 1858.			Longitude.				R.N.P.D.		
			B—O	Corr. to B.	H—B	H—O	B—O	H—B	H—O
d	h	m							
Aug. 1	17	22	+18·8	−0·9	−15·9	+2·0	−4·2	+3·2	−1·0
2	18	15	+20·2	−1·1	−16·5	+2·6	−3·9	+2·9	−1·0
4	20	16	+13·4	−0·9	−10·4	+2·1	−8·5	+0·1	−8·4
13	3	33	+17·3	−0·8	−20·6	−4·1	+3·3	−3·5	−0·2
19	8	24	+ 6·0	−0·5	− 6·1	−0·6	−6·2	+5·5	−0·7
20	9	15	+ 2·9	−0·3	− 5·7	−3·1	−9·5	+5·8	−3·7
22	10	52	+ 2·1	−0·3	− 5·3	−3·5	−6·1	+4·7	−1·4
23	11	37	+ 2·5	−0·3	− 6·4	−4·2	−4·4	+3·8	−0·6
24	12	21	+ 7·7	−0·5	− 7·4	−0·2	−2·8	+3·0	+0·2
25	13	4	+ 9·8	−0·5	− 7·5	+1·8	−3·5	+2·5	−1·0
27	14	32	+10·6	−0·6	− 7·4	+2·6	−2·2	+2·1	−0·1
28	15	19	+12·9	−0·7	− 9·1	+3·1	−2·0	+2·5	+0·5
30	17	7	+14·4	−0·9	−15·0	−1·5	−4·3	+2·0	−2·3
31	18	7	+18·6	−1·1	−16·1	+1·4	−3·4	+1·2	−2·2
Sept. 1	19	10	+16·5	−1·1	−14·8	+0·6	+3·1	−0·3	+2·8
12	3	43	+13·3	−0·7	−17·2	−4·6	+0·8	−1·5	−0·7
13	4	33	+ 8·0	−0·5	−11·7	−4·2	+0·2	+0·5	+0·7
15	6	15	+ 0·6	−0·3	− 4·8	−4·5	−2·1	+3·0	+0·9
16	7	7	− 3·9	−0·1	− 4·0	−8·0	−6·2	+3·8	−2·4
18	8	45	− 1·0	−0·2	− 4·0	−5·2	−6·2	+4·6	−1·6
21	10	59	+ 1·8	−0·2	− 6·5	−4·9	−8·1	+4·3	−3·8
22	11	43	+ 7·7	−0·5	− 8·0	−0·8	−4·9	+3·6	−1·3
23	12	28	+ 9·5	−0·5	− 9·1	−0·1	−4·4	+2·8	−1·6
24	13	15	+12·0	−0·7	− 9·5	+1·8	−3·6	+2·4	−1·2
25	14	6	+13·7	−0·8	− 9·9	+3·0	−2·7	+2·1	−0·6
30	19	7	+19·3	−1·1	−15·6	+2·6	+4·3	−1·0	+3·3
Oct. 2	20	56	+18·5	−0·9	−13·9	+3·7	+5·2	−4·3	+0·9
15	6	37	− 1·9	−0·1	− 4·1	−6·1	−6·0	+4·3	−1·7
16	7	23	− 1·5	−0·1	− 3·4	−5·0	−8·7	+5·0	−3·7
17	8	8	− 0·9	−0·2	− 3·1	−4·2	−5·7	+5·6	−0·1
20	10	19	+ 2·3	−0·2	− 6·3	−4·2	−7·6	+6·0	−1·6
22	11	57	+15·1	−0·9	−12·6	+1·6	−2·7	+3·8	+1·1
28	18	0	+18·3	−1·0	−15·7	+1·6	+3·0	−3·8	−0·8
29	18	53	+21·0	−1·0	−16·4	+3·6	+7·8	−5·4	+2·4
Nov. 11	4	30	+ 8·6	−0·5	−11·7	−3·6	−7·1	+4·1	−3·0
12	5	16	+ 4·1	−0·3	− 9·1	−5·3	−5·5	+4·5	−1·0
13	6	1	+ 1·5	−0·2	− 8·0	−6·7	−7·3	+5·2	−2·1
15	7	26	+ 3·2	−0·3	− 8·5	−5·6	−8·0	+6·9	−1·1
17	8	54	+ 2·2	−0·2	−10·4	−8·4	−8·5	+7·5	−1·0
18	9	42	+ 9·6	−0·6	−12·0	−3·0	−6·3	+6·8	+0·5
20	11	34	+14·4	−0·9	−16·2	−2·7	−5·2	+3·8	−1·4

Approx. G.M.T. 1858.			Longitude.				E.N.P.D.		
			B—O	Corr. to B.	H—B	H—O	B—O	H—B	H—O
	d h m								
Nov. 21	12 38		+16·1	−1·1	−16·8	−1·8	−1·8	+2·1	+0·3
22	13 44		+16·9	−1·1	−16·2	−0·4	−1·1	+0·1	−1·0
23	14 50		+16·2	−1·1	−14·8	+0·3	+4·0	−1·4	+2·6
26	17 40		+16·6	−0·8	−14·2	+1·6	+8·1	−7·7	+0·4
Dec. 17	9 14		+15·4	−0·9	−21·6	−7·1	−4·6	+3·7	−0·9
18	10 14		+16·8	−1·0	−21·4	−5·6	−4·6	+2·6	−2·0
19	11 20		+20·2	−1·3	−21·6	−2·7	−3·6	+1·2	−2·4
21	13 34		+19·7	−1·2	−18·7	−0·2	+1·9	−1·2	+0·7
23	15 31		+15·4	−0·9	−11·9	+2·6	+5·3	−3·7	+1·6
24	16 22		+12·3	−0·7	−10·4	+1·2	+4·8	−4·8	0·0
26	17 53		+15·1	−0·7	−12·0	+2·4	+7·8	−5·5	+2·3
27	18 38		+13·4	−0·6	−12·6	+0·2	+7·2	−4·4	+2·8
28	19 22		+13·4	−0·7	−11·2	+1·5	+4·9	−2·7	+2·2

Approx. G.M.T. 1859.			Longitude.				E.N.P.D.		
			B−0	Corr. to B.	H−B	H−0	B−0	H−B	H−0
	d	h m	″	″	″	″	″	″	″
Jan.	14	7 55	+ 16·3	− 1·0	− 21·1	− 5·8	− 2·4	+ 0·2	− 2·2
	15	8 56	+ 20·1	− 1·2	− 23·5	− 4·6	+ 0·4	− 0·3	+ 0·1
	16	10 2	+ 18·0	− 1·2	− 24·6	− 7·8	+ 2·4	− 1·3	+ 1·1
	18	12 14	+ 25·9	− 1·5	− 25·6	− 1·2	+ 3·3	− 2·8	+ 0·5
	19	13 14	+ 25·2	− 1·3	− 24·9	− 1·0	+ 4·3	− 3·2	+ 1·1
	21	14 59	+ 13·1	− 0·8	− 17·4	− 5·1	+ 1·5	− 2·7	− 1·2
	22	15 46	+ 16·3	− 0·9	− 14·2	+ 1·2	+ 1·3	− 2·1	− 0·8
	23	16 32	+ 14·9	− 0·8	− 12·5	+ 1·6	+ 2·8	− 0·8	+ 2·0
	25	18 5	+ 12·1	− 0·7	− 11·6	− 0·2	− 1·0	+ 2·4	+ 1·4
	26	18 53	+ 4·3	− 0·4	− 9·9	− 6·0	− 2·6	+ 3·9	+ 1·3
Feb.	10	5 45	+ 1·9	− 0·3	− 7·3	− 5·7	− 2·1	+ 0·9	− 1·2
	12	7 44	+ 12·9	− 0·9	− 16·2	− 4·2	+ 0·5	− 0·2	+ 0·3
	13	8 47	+ 14·7	− 1·0	− 20·3	− 6·6	+ 1·1	− 1·4	− 0·3
	14	9 52	+ 20·1	− 1·2	− 23·0	− 4·1	+ 3·0	− 2·9	+ 0·1
	15	10 54	+ 20·9	− 1·2	− 24·5	− 4·8	+ 5·1	− 4·0	+ 1·1
	16	11 51	+ 23·3	− 1·2	− 25·4	− 3·3	+ 6·3	− 5·0	+ 1·3
	17	12 44	+ 25·1	− 1·2	− 25·0	− 1·1	+ 6·3	− 4·9	+ 1·4
	18	13 34	+ 21·5	− 1·0	− 23·2	− 2·7	+ 5·8	− 4·4	+ 1·4
	20	15 9	+ 20·3	− 1·0	− 17·4	+ 1·9	+ 4·6	− 1·3	+ 3·3
	22	16 46	+ 11·0	− 0·7	− 12·9	− 2·6	− 2·7	+ 2·4	− 0·3
	24	18 28	+ 10·3	− 0·7	− 10·5	− 0·9	− 5·8	+ 5·3	− 0·5
Mar.	9	3 42	− 2·5	− 0·2	− 6·2	− 8·9	− 2·9	+ 2·1	− 0·8
	10	4 36	+ 2·5	− 0·4	− 7·3	− 5·2	− 4·1	+ 2·4	− 1·7
	15	9 37	+ 20·1	− 1·1	− 22·6	− 3·6	+ 3·3	− 3·9	− 0·6
	18	12 9	+ 13·1	− 0·7	− 16·4	− 4·0	+ 5·6	− 6·1	− 0·5
	19	12 57	+ 12·4	− 0·6	− 14·6	− 2·8	+ 7·8	− 4·9	+ 2·9
Apr.	7	3 30	+ 4·4	− 0·5	− 9·8	− 5·9	+ 0·4	+ 0·9	+ 1·3
	10	6 33	+ 20·3	− 1·2	− 21·0	− 1·9	− 0·9	− 0·8	− 1·7
	11	7 30	+ 20·8	− 1·1	− 23·4	− 3·7	+ 1·6	− 2·6	− 1·0
	13	9 12	+ 20·4	− 0·9	− 22·4	− 2·9	+ 6·5	− 6·0	+ 0·5
	15	10 47	+ 10·9	− 0·6	− 13·6	− 3·3	+ 5·1	− 6·0	− 0·9
	16	11 35	+ 5·7	− 0·4	− 9·8	− 4·5	+ 6·2	− 5·0	+ 1·2
	17	12 23	+ 6·7	− 0·5	− 7·6	− 1·4	+ 4·3	− 3·6	+ 0·7
	18	13 14	+ 6·0	− 0·5	− 7·2	− 1·7	+ 3·1	− 1·8	+ 1·3
	21	15 53	+ 5·3	− 0·5	− 8·8	− 4·0	− 3·7	+ 2·8	− 0·9
	22	16 45	+ 9·9	− 0·6	− 9·6	− 0·3	− 5·0	+ 4·0	− 1·0

Approx. G.M.T. 1859.			Longitude.			R.N.P.D.		
		B−O	Corr. to B.	H−B	H−O	B−O	H−B	H−O
May d h m		″	″	″	″	″	″	″
8 5 26		+15·9	−0·9	−18·9	−3·9	+ 2·0	−2·5	−0·5
9 6 19		+16·9	−0·9	−18·2	−2·2	+ 2·9	−3·9	−1·0
11 7 57		+14·7	−0·7	−18·6	−4·6	+ 5·8	−6·0	−0·2
12 8 43		+16·3	−0·8	−17·9	−2·4	+ 4·1	−6·0	−1·9
13 9 28		+11·4	−0·6	−15·9	−5·1	+ 5·6	−5·0	+0·6
14 10 16		+11·0	−0·6	−12·8	−2·4	+ 3·7	−3·7	0·0
15 11 5		+ 5·5	−0·4	−10·4	−5·3	+ 3·8	−2·4	+1·4
21 16 15		+ 7·2	−0·4	− 7·4	−0·6	−12·9	+4·3	−8·6
23 17 43		+ 9·3	−0·4	− 5·9	+3·0	− 8·4	+6·7	−1·7
24 18 24		+ 2·5	−0·2	− 4·2	−1·9	− 7·1	+7·7	+0·6
26 19 46		− 3·0	0·0	+ 1·3	−1·7	−10·8	+9·0	−1·8
June 7 5 55		+10·3	−0·6	−15·1	−5·4	+ 3·0	−3·2	−0·2
8 6 41		+ 9·3	−0·6	−13·2	−4·5	+ 4·0	−3·6	+0·4
9 7 27		+ 8·6	−0·5	−12·8	−4·7	+ 2·4	−3·1	−0·7
12 9 51		+ 8·4	−0·6	−10·7	−2·9	− 1·7	+0·7	−1·0
15 12 29		+ 6·2	−0·5	−11·7	−6·0	− 2·5	+2·7	+0·2
16 13 21		+ 7·5	−0·5	−11·3	−4·3	− 2·6	+2·8	+0·2
17 14 10		+ 5·5	−0·4	− 9·5	−4·4	− 1·7	+2·8	+1·1
20 16 20		+ 5·9	−0·4	− 4·1	+1·4	− 0·5	+3·6	+3·1
22 17 41		+ 3·8	−0·3	− 5·7	−2·2	− 5·3	+5·9	+0·6
23 18 22		+ 4·1	−0·3	− 6·8	−3·0	− 6·0	+6·8	+0·8
24 19 6		+ 3·8	−0·3	− 7·3	−3·8	−10·1	+7·4	−2·7
July 5 4 38		+18·8	−0·9	−22·9	−5·0	+ 2·2	−1·8	+0·4
8 6 59		+ 6·5	−0·5	−11·0	−5·0	− 2·2	+1·0	−1·2
9 7 48		+ 5·0	−0·5	− 9·2	−4·7	+ 1·4	+2·5	+3·9
10 8 39		+ 4·0	−0·4	− 7·8	−4·2	− 2·7	+3·6	+0·9
11 9 32		+ 1·7	−0·3	− 6·8	−5·4	− 3·8	+4·3	+0·5
12 10 24		+ 1·9	−0·3	− 7·0	−5·4	− 3·6	+4·4	+0·8
14 12 6		+ 1·7	−0·3	− 8·4	−7·0	− 3·5	+3·5	0·0
15 12 53		+ 6·6	−0·4	− 8·5	−2·3	− 5·7	+2·9	−2·8
16 13 37		+ 4·4	−0·4	− 7·5	−3·5	− 2·4	+2·0	−0·4
17 14 19		+ 5·3	−0·4	− 6·1	−1·2	− 0·9	+1·5	+0·6
21 17 1		+10·3	−0·6	−10·2	−0·5	− 1·9	+2·0	+0·1
23 18 36		+13·8	−0·7	−13·9	−0·8	− 5·8	+3·2	−2·6
24 19 31		+14·3	−0·8	−13·1	+0·4	− 6·4	+2·9	−3·5
Aug. 4 4 54		+14·4	−0·9	−20·5	−7·0	− 6·4	−1·4	−7·8
12 11 35		− 0·2	−0·2	− 3·8	−4·2	− 2·9	+3·4	+0·5
13 12 18		+ 2·6	−0·3	− 4·3	−2·0	− 3·9	+2·4	−1·5
14 12 59		+ 6·8	−0·5	− 5·2	+1·1	− 1·4	+1·7	+0·3
15 13 39		+ 4·8	−0·4	− 6·4	−2·0	− 1·2	+0·7	−0·5
16 14 19		+ 8·6	−0·5	− 7·5	+0·6	− 1·3	+0·4	−0·9

Approx. G.M.T. 1859.	B−0	Longitude. Corr. to B.	H−B	H−0	R.N.P.D. B−0	H−B	H−0
d h m	″	″	″	″	″	″	″
Aug. 18 15 43	+ 11.2	−0.6	−10.9	−0.3	− 3.3	+0.1	−3.2
19 16 30	+ 16.3	−0.8	−13.2	+2.3	− 1.9	+0.6	−1.3
20 17 22	+ 16.2	−0.9	−15.1	+0.2	− 3.0	+0.7	−2.3
21 18 18	+ 19.2	−1.1	−15.8	+2.3	− 1.6	+0.5	−1.1
22 19 18	+ 15.4	−1.0	−14.7	−0.3	− 0.9	+0.2	−0.7
Sept. 6 7 58	+ 3.3	−0.4	− 8.5	−5.6	− 1.5	+2.4	+0.9
9 10 16	− 0.6	−0.2	− 4.5	−5.3	− 1.4	+3.1	+1.7
10 10 58	− 1.3	−0.2	− 4.5	−6.0	− 1.3	+2.4	+1.1
11 11 38	+ 1.2	−0.3	− 6.3	−5.4	− 2.6	+2.1	−0.5
12 12 18	+ 10.1	−0.6	− 8.5	+1.0	+ 0.1	+1.5	+1.6
14 13 42	+ 10.7	−0.6	−11.4	−1.3	− 3.3	+0.4	−2.9
15 14 28	+ 13.4	−0.7	−11.7	+1.0	− 1.6	+0.3	−1.3
16 15 18	+ 13.0	−0.7	−11.4	+0.9	− 1.6	+0.9	−0.7
17 16 12	+ 13.2	−0.8	−12.6	−0.2	− 1.5	+1.2	−0.3
21 20 10	+ 15.2	−0.9	−13.2	+1.1	+ 2.3	−1.2	+1.1
Oct. 2 4 59	+ 12.8	−0.8	−18.2	−6.2	+ 0.2	+0.1	+0.3
3 5 51	+ 8.9	−0.6	−13.3	−5.0	− 2.3	+1.1	−1.2
4 6 41	+ 4.8	−0.4	−10.3	−5.9	− 0.8	+2.1	+1.3
5 7 28	+ 0.7	−0.3	− 8.7	−8.3	− 1.8	+2.8	+1.0
6 8 13	+ 2.1	−0.3	− 7.7	−5.9	− 3.7	+3.7	0.0
8 9 35	+ 1.2	−0.3	− 7.2	−6.3	− 2.4	+4.0	+1.6
12 12 25	+ 20.7	−1.0	−16.6	+3.1	− 2.9	+1.9	−1.0
20 19 51	+ 21.9	−1.1	−15.7	+5.1	+ 1.2	−3.4	−2.2
21 20 41	+ 16.6	−0.8	−14.2	+1.6	+ 6.1	−3.8	+2.3
Nov. 3 6 50	+ 1.4	−0.2	− 6.2	−5.0	− 5.7	+4.7	−1.0
4 7 31	− 0.6	−0.2	− 6.3	−7.1	− 6.5	+5.3	−1.2
7 9 34	+ 10.8	−0.5	−12.0	−1.7	−11.2	+5.5	−5.7
8 10 18	+ 11.1	−0.6	−15.7	−5.2	− 4.6	+4.9	+0.3
9 11 7	+ 16.8	−0.8	−19.1	−3.1	− 4.7	+4.1	−0.6
10 12 0	+ 21.7	−1.1	−20.2	+0.4	− 3.6	+3.0	−0.6
11 12 57	+ 22.7	−1.2	−19.6	+1.9	− 3.2	+2.1	−1.1
12 13 57	+ 23.3	−1.3	−17.8	+4.2	− 3.5	+1.1	−2.4
13 14 58	+ 19.8	−1.2	−16.3	+2.3	− 0.5	−0.4	−0.9
14 15 57	+ 20.2	−1.1	−16.0	+3.1	+ 3.7	−1.9	+1.8
15 16 55	+ 21.9	−1.2	−16.7	+4.0	+ 1.7	−3.6	−1.9
17 18 37	+ 23.8	−1.1	−19.6	+3.1	+ 7.3	−6.4	+0.9
18 19 26	+ 24.7	−1.1	−20.2	+3.4	+ 6.2	−6.6	−0.4
19 20 13	+ 23.8	−1.0	−19.8	+3.0	+ 6.6	−5.4	+1.2
Dec. 1 5 26	0.0	−0.2	− 6.1	−6.3	− 3.7	+3.7	0.0
2 6 6	− 0.9	−0.2	− 6.1	−7.2	− 4.2	+4.1	−0.1

Approx. G.M.T. 1859			Longitude.				R.N.P.D.		
			B−O	Corr. to B.	H−B	H−O	B−O	H−B	H−O
d	h	m							
Dec. 5	8	9	+ 7·0	−0·4	−11·8	− 5·2	−4·2	+4·1	−0·1
6	8	55	+ 7·9	−0·5	−14·4	− 7·0	−3·9	+3·8	−0·1
8	10	42	+15·0	−0·9	−19·9	− 5·8	−5·2	+2·5	−2·7
9	11	42	+22·0	−1·2	−21·7	− 0·9	−2·4	+1·6	−0·8
10	12	45	+22·2	−1·3	−22·8	− 1·9	−1·2	+0·8	−0·4
11	13	47	+23·3	−1·3	−22·3	− 0·3	+2·4	−0·6	+1·8
13	15	43	+24·3	−1·2	−19·0	+ 4·1	+3·7	−4·1	−0·4
14	16	35	+20·8	−1·0	−19·0	+ 0·8	+6·6	−5·9	+0·7
17	18	59	+27·5	−1·1	−23·3	+ 3·1	+8·6	−5·0	+3·6
19	20	37	+19·4	−0·9	−17·5	+ 1·0	+7·3	−0·3	+7·0
30	4	41	− 5·1	−0·1	− 5·4	−10·6	−1·8	+0·3	−1·5

Errors of Hansen's Tables deduced

Approx. G.M.T. 1860			Longitude.				R.N.P.D.		
			B−O	Corr. to B.	H−B	H−O	B−O	H−B	H−O
	d	h m	"	"	"	"	"	"	"
Jan. 2	6	45	+ 6·1	−0·5	−11·4	−5·8	− 0·9	+0·3	−0·6
3	7	33	+ 7·0	−0·5	−15·0	−8·5	− 0·4	+0·2	−0·2
4	8	25	+11·0	−0·7	−17·8	−7·5	− 1·2	+0·3	−0·9
6	10	24	+19·4	−1·2	−23·0	−4·8	− 0·1	−0·3	−0·4
7	11	28	+19·8	−1·2	−25·5	−6·9	− 1·1	−0·7	−1·8
8	12	31	+26·0	−1·5	−27·1	−2·6	+ 1·9	−1·7	+0·2
9	13	30	+26·7	−1·4	−26·8	−1·5	+ 4·1	−2·6	+1·5
15	18	34	+25·1	−1·3	−20·6	+3·2	− 4·6	+1·6	−3·0
16	19	26	+17·2	−1·0	−16·9	−0·7	− 2·9	+3·8	+0·9
28	3	58	+ 3·2	−0·4	− 6·0	−3·2	+ 2·7	−0·8	+1·9
31	6	13	+ 5·6	−0·5	−11·2	−6·1	+ 0·8	−1·2	−0·4
Feb. 2	8	4	+14·5	−0·9	−20·0	−6·4	+ 1·5	−1·3	+0·2
3	9	6	+19·3	−1·2	−23·8	−5·7	+ 0·8	−1·6	−0·8
6	12	8	+27·7	−1·4	−29·5	−3·2	+ 3·7	−3·0	+0·7
9	14	47	+25·9	−1·3	−22·6	+2·0	+ 3·1	−1·2	+1·9
10	15	37	+21·0	−1·1	−19·0	+0·9	+ 1·9	+0·2	+2·1
11	16	29	+16·9	−1·0	−16·2	−0·3	− 0·9	+2·0	+1·1
14	19	10	+ 9·2	−0·7	− 9·6	−1·1	− 7·1	+7·2	+0·1
25	2	39	+ 2·2	−0·3	− 6·0	−4·1	− 0·7	+0·6	−0·1
29	5	53	+ 6·8	−0·5	−11·5	−5·2	− 0·6	+1·1	+0·5
Mar. 1	6	51	+12·3	−0·8	−16·3	−4·8	− 0·3	+0·7	+0·4
2	7	50	+14·7	−0·9	−21·4	−7·6	− 0·8	−0·3	−1·1
3	8	50	+19·3	−1·1	−24·7	−6·5	+ 1·1	−1·5	−0·4
4	9	49	+22·0	−1·2	−25·8	−5·0	+ 3·6	−2·7	+0·9
5	10	45	+23·1	−1·2	−25·8	−3·9	+ 3·3	−3·7	−0·4
7	12	31	+27·7	−1·3	−24·1	+2·3	+ 8·8	−3·4	+5·4
9	14	16	+21·4	−1·1	−18·7	+1·6	+ 4·8	−1·2	+3·6
11	16	5	+11·0	−0·7	−10·6	−0·3	+ 5·0	+1·9	+6·9
12	17	2	+ 7·0	−0·6	− 9·0	−2·6	− 6·7	+3·4	−3·3
14	18	51	+ 8·4	−0·6	− 7·4	+0·4	−13·0	+6·0	−7·0
Apr. 1	8	31	+21·9	−1·1	−24·9	−4·1	+ 4·1	−3·5	+0·6
2	9	24	+21·4	−1·1	−23·3	−3·0	+ 3·9	−4·8	−0·9
3	10	16	+17·1	−0·9	−21·0	−4·8	+ 5·1	−5·3	−0·2
4	11	7	+14·3	−0·8	−18·9	−5·4	+ 5·0	−5·1	−0·1
6	12	54	+15·2	−0·8	−15·7	−1·3	+ 5·7	−3·6	+2·1
7	13	50	+11·9	−0·7	−13·9	−2·7	+ 3·7	−2·5	+1·2
8	14	47	+10·7	−0·7	−11·9	−1·9	+ 1·3	−1·1	+0·2

Approx. G.M.T. 1860.			Longitude.				E.N.P.D.		
			B-O	Corr. to B.	H-B	H-O	B-O	H-B	H-O
d	h	m	"	"	"	"	"	"	"
Apr. 9	15	45	+ 9.5	-0.7	-10.7	-1.9	-2.3	+0.2	-2.1
10	16	42	+ 7.8	-0.6	-10.0	-2.8	-5.0	+1.6	-3.4
27	5	30	+18.3	-1.0	-22.3	-5.0	+1.2	-1.7	-0.5
28	6	24	+19.1	-1.0	-24.4	-6.3	+4.8	-3.1	+1.7
29	7	16	+23.6	-1.1	-25.2	-2.7	+6.6	-4.5	+2.1
30	8	6	+19.8	-1.0	-24.1	-5.3	+5.3	-5.3	0.0
May 1	8	56	+17.7	-0.9	-21.8	-5.0	+5.7	-5.4	+0.3
2	9	47	+16.0	-0.8	-19.0	-3.8	+5.6	-4.8	+0.8
3	10	39	+12.4	-0.7	-17.0	-5.3	+4.3	-3.9	+0.4
4	11	33	+11.3	-0.7	-16.2	-5.6	+5.0	-3.1	+1.9
6	13	29	+11.9	-0.8	-13.7	-2.6	-0.2	-1.5	-1.7
28	6	52	+18.5	-0.9	-21.0	-3.4	+2.7	-3.4	-0.7
29	7	41	+15.4	-0.8	-20.2	-5.6	+3.8	-2.6	+1.2
30	8	30	+14.3	-0.8	-19.8	-6.3	+0.9	-1.5	-0.6
June 3	12	13	+10.9	-0.8	-14.7	-4.6	-0.3	+1.5	+1.2
10	17	48	+ 2.6	-0.3	- 6.3	-4.0	-0.4	+1.9	+1.5
11	18	28	+ 5.8	-0.4	- 5.7	-0.3	-0.9	+2.2	+1.3
12	19	8	+ 1.6	-0.3	- 4.9	-3.6	-4.0	+2.5	-1.5
14	20	36	- 0.5	-0.4	- 3.8	-4.7	-2.7	+3.5	+0.8
25	5	38	+15.7	-0.9	-21.0	-6.2	0.0	-0.2	-0.2
26	6	27	+13.7	-0.8	-17.8	-4.9	-1.1	+0.8	-0.3
30	10	3	+13.0	-0.8	-14.9	-2.7	-4.7	+4.6	-0.1
July 1	11	0	+12.4	-0.8	-14.8	-3.2	-7.2	+4.4	-2.8
3	12	48	+10.5	-0.6	-13.8	-3.9	-4.9	+3.1	-1.8
4	13	36	+ 7.6	-0.5	-12.3	-5.2	-1.3	+2.0	+0.7
6	15	4	+ 2.8	-0.4	- 6.2	-3.8	+2.2	-0.3	+1.9
7	15	44	+ 3.3	-0.4	- 4.1	-1.2	+4.3	-1.3	+3.0
29	9	49	+ 7.1	-0.5	-10.9	-4.3	-6.7	+4.3	-2.4
30	10	42	+ 6.1	-0.5	-11.3	-5.7	-4.3	+4.2	-0.1
Aug. 4	14	21	+ 5.3	-0.5	- 6.3	-1.5	+3.0	-2.1	+0.9
6	15	41	+ 3.2	-0.4	- 3.8	-1.0	+2.0	-3.3	-1.3
27	9	28	+ 2.9	-0.3	- 7.6	-5.0	-3.0	+2.5	-0.5
29	10	59	+ 3.0	-0.3	- 9.0	-6.3	-1.2	+1.7	+0.5
30	11	46	+ 7.6	-0.5	-11.1	-4.0	-2.2	+0.5	-1.7
31	12	20	+11.2	-0.6	-12.4	-1.8	+2.8	-0.7	+2.1
Sept. 1	13	0	+10.4	-0.6	-12.4	-2.6	+1.8	-2.0	-0.2
4	15	5	+ 8.7	-0.6	- 7.7	+0.4	+2.2	-3.1	-0.9
5	15	51	+ 9.9	-0.6	- 8.2	+1.1	+1.2	-2.7	-1.5
10	20	25	+18.9	-1.0	-17.1	+0.8	+3.7	-2.7	+1.0

Errors of Hansen's Tables deduced

Approx. G.M.T. 1860			B−O	Longitude. Corr. to B.	H−B	H−O	R.N.P.D. B−O	H−B	H−O
	d	h m	+ ″	− ″	− ″	− ″	− ″	+ ″	− ″
Sept. 25	8	58	+ 0·9	− 0·3	− 8·3	− 7·7	− 2·4	+ 2·2	− 0·2
Oct. 2	13	49	+ 19·0	− 0·9	− 15·5	+ 2·6 .	+ 3·1	− 3·2	− 0·1
3	14	37	+ 14·2	− 0·8	− 14·0	− 0·6	+ 2·2	− 2·7	− 0·5
4	15	29	+ 8·9	− 0·6	− 13·3	− 5·0	− 0·9	− 1·9	− 2·8
5	16	23	+ 13·8	− 0·8	− 14·4	− 1·4	− 2·9	− 1·9	− 4·8
7	18	14	+ 19·6	− 1·0	− 19·6	− 1·0	+ 4·5	− 2·5	+ 2·0
8	19	8	+ 20·9	− 1·1	− 20·9	− 1·1	+ 3·3	− 2·9	+ 0·4
20	5	19	+ 12·5	− 0·7	− 17·9	− 6·1	− 6·4	+ 4·4	− 2·0
22	6	55	+ 4·1	− 0·3	− 10·9	− 7·1	− 4·6	+ 4·2	− 0·4
26	9	38	+ 6·2	− 0·4	− 13·3	− 7·5	− 0·3	+ 0·2	− 0·1
27	10	19	+ 10·2	− 0·6	− 14·9	− 5·3	+ 0·7	− 0·8	− 0·1
28	11	1	+ 13·4	− 0·7	− 16·8	− 4·1	+ 0·1	− 1·8	− 1·7
31	13	25	+ 18·6	− 1·0	− 19·5	− 1·9	+ 1·5	− 2·1	− 0·6
Nov. 1	14	19	+ 17·4	− 0·9	− 17·6	− 1·1	− 0·5	− 1·5	− 2·0
2	15	14	+ 13·5	− 0·8	− 15·5	− 2·8	+ 0·3	− 1·1	− 0·8
3	16	9	+ 13·2	− 0·8	− 15·0	− 2·6	+ 3·3	− 1·4	+ 1·9
18	4	48	+ 8·8	− 0·5	− 13·7	− 5·4	− 5·6	+ 5·3	− 0·3
19	5	33	+ 3·3	− 0·3	− 10·3	− 7·3	− 4·5	+ 4·5	0·0
20	6	15	− 0·3	− 0·2	− 9·3	− 9·8	− 2·6	+ 3·5	+ 0·9
22	7	35	+ 4·4	− 0·4	− 11·6	− 7·6	− 0·6	+ 0·8	+ 0·2
30	14	4	+ 18·1	− 1·0	− 18·2	− 1·1	+ 1·5	− 1·1	+ 0·4
Dec. 6	19	9	+ 26·5	− 1·3	− 22·6	+ 2·6	− 0·4	− 0·1	− 0·5
20	6	11	+ 0·3	− 0·3	− 8·4	− 8·4	+ 1·2	− 1·6	− 0·4
22	7	34	+ 2·6	− 0·4	− 11·2	− 9·0	+ 3·3	− 3·3	0·0
23	8	20	+ 4·3	− 0·5	− 12·2	− 8·4	+ 3·6	− 3·6	0·0
24	9	9	+ 10·9	− 0·7	− 13·5	− 3·3	+ 3·5	− 3·5	0·0
27	11	54	+ 12·9	− 0·8	− 20·2	− 8·1	+ 1·5	− 2·1	− 0·6
28	12	51	+ 20·5	− 1·1	− 20·6	− 1·2	+ 3·0	− 1·7	+ 1·3

Approx. G.M.T. 1861.			B−O	Longitude. Corr. to B.	H−B	H−O	N.P.D. B−O	H−B	H−O
	d	h m							
Jan.	2	17 6	+25ʺ·6	−1ʺ·3	−22ʺ·1	+2ʺ·2	−0ʺ·9	+0ʺ·1	−0ʺ·8
	3	17 56	+27·0	−1·3	−23·4	+2·3	+1·9	+1·5	+3·4
	5	19 42	+20·1	−1·2	−20·4	−1·5	−6·5	+5·8	−0·7
	21	7 49	+ 7·2	−0·6	−13·9	−7·3	+3·2	−4·3	−1·1
	24	10 36	+12·8	−0·8	−18·9	−6·9	+1·5	−3·2	−1·7
	27	13 20	+21·3	−1·1	−22·6	−2·4	+3·3	−0·6	+2·7
	28	14 11	+25·0	−1·2	−23·1	+0·7	+0·9	+0·4	+1·3
Feb.	1	17 38	+20·6	−1·2	−20·4	−1·0	−4·4	+5·8	+1·4
	17	5 40	+ 2·0	−0·4	−10·3	−8·7	+3·4	−3·0	+0·4
	18	6 31	+ 9·1	−0·6	−13·4	−4·9	+0·8	−3·1	−2·3
	21	9 16	(+13·6)	−0·8	−17·9	(−5·1)	(+6·8)	−3·3	(+3·5)
	25	12 50	+22·1	−1·2	−21·4	−0·5	−4·3	+1·1	−3·2
	26	13 42	+24·6	−1·3	−21·0	+2·3	−0·2	+2·5	+2·3
Mar.	1	16 28	+12·1	−0·9	−13·2	−2·0	−5·2	+6·3	+1·1
	18	5 15	+ 5·6	−0·5	−12·6	−7·5	+4·6	−1·8	+2·8
	21	7 56	+14·5	−0·8	−18·6	−4·9	+3·8	−3·6	+0·2
	22	8 50	+12·8	−0·7	−18·4	−6·3	+4·4	−3·9	+0·5
	23	9 42	+14·7	−0·8	−17·4	−3·5	+4·1	−3·6	+0·5
	26	12 20	+18·3	−1·0	−17·8	−0·5	+0·5	+0·4	+0·9
	28	14 14	+14·0	−0·9	−14·9	−1·8	−1·8	+3·1	+1·3
Apr.	16	4 55	+ 9·6	−0·6	−16·5	−7·5	+2·6	−2·5	+0·1
	17	5 48	+12·1	−0·7	−17·8	−6·4	+3·3	−3·0	+0·3
	18	6 40	+14·7	−0·8	−19·3	−5·4	+3·4	−4·1	−0·7
	20	8 20	+16·4	−0·8	−20·3	−4·7	+5·6	−4·6	+1·0
	21	9 11	+15·5	−0·8	−19·2	−4·5	+3·0	−4·2	−1·2
	23	10 57	+11·7	−0·8	−17·8	−6·9	+2·1	−1·3	+0·8
	24	11 55	+16·7	−1·0	−18·3	−2·6	+2·7	0·0	+2·7
	25	12 56	+18·2	−1·1	−19·1	−2·0	−1·2	+0·9	−0·3
	27	15 1	+14·1	−0·9	−15·7	−2·5	−3·3	+2·6	−0·7
	29	16 57	+ 7·4	−0·6	− 8·3	−1·5	−4·0	+3·9	−0·1
May	17	6 14	+15·7	−0·8	−20·7	−5·8	+4·6	−2·6	+2·0
	18	7 2	+18·3	−0·9	−21·6	−4·2	+3·3	−2·3	+1·0
	19	7 52	+17·8	−0·9	−21·4	−4·5	+2·8	−1·7	+1·1
	21	9 37	+11·9	−0·8	−17·7	−6·6	−0·6	+0·9	+0·3
	22	10 36	+12·5	−0·9	−17·9	−6·3	−0·4	+2·0	+1·6
	24	12 41	+19·4	−1·2	−20·4	−2·2	+2·0	+3·4	+5·4

Approx. G.M.T. 1861.			Longitude.			E.N.P.D.		
d h m	B−O	Corr. to B.	H−B	H−O		B−O	H−B	H−O
June 14 4 59	+19·9	−1·0	−21·8	−2·9		+1·8	+0·8	+2·6
15 5 47	+19·3	−1·0	−21·5	−3·2		+0·2	+1·3	+1·5
16 6 36	+17·4	−1·0	−20·2	−3·8		−0·4	+2·3	+1·9
17 7 28	+14·2	−0·9	−18·4	−5·1		−2·1	+3·5	+1·4
18 8 22	+16·7	−1·0	−16·9	−1·2		−1·8	+4·8	+3·0
19 9 21	+13·6	−1·0	−16·4	−3·8		−6·1	+6·1	0·0
20 10 22	+13·6	−1·0	−16·7	−4·1		−7·8	+6·9	−0·9
22 12 26	+13·2	−0·8	−16·5	−4·1		−5·5	+6·9	+1·4
25 15 5	+10·9	−0·6	−12·2	−1·9		−0·8	+2·5	+1·7
26 15 50	+ 9·8	−0·6	−10·5	−1·3		−0·1	+0·5	+0·4
27 16 32	+ 6·8	−0·5	− 9·2	−2·9		+1·2	−1·4	−0·2
30 18 36	+ 7·7	−0·5	− 7·4	−0·2		+1·8	−4·9	−3·1
July 2 20 6	+10·9	−0·6	− 5·9	+4·4		−0·5	−4·5	−5·0
15 6 17	+15·0	−0·9	−18·2	−4·1		−2·0	+3·6	+1·6
18 9 12	+16·2	−1·0	−16·1	−0·9		−7·0	+7·1	+0·1
20 11 10	+10·9	−0·7	−15·4	−5·2		−7·4	+8·0	+0·6
23 13 42	+12·5	−0·6	−13·4	−1·5		−4·9	+3·6	−1·3
29 17 59	+ 6·2	−0·5	− 5·8	−0·1		+4·7	−4·2	+0·5
30 18 46	+ 7·3	−0·5	− 6·8	0·0		+3·5	−4·2	−0·7
Aug. 15 8 4	+12·5	−0·8	−15·1	−3·4		−5·3	+3·4	−1·9
17 9 57	+ 9·2	−0·6	−15·6	−7·0		−5·3	+5·0	−0·3
18 10 48	+14·5	−0·8	−16·4	−2·7		−5·2	+4·8	−0·4
19 11 36	+12·5	−0·7	−17·9	−6·1		−3·9	+3·8	−0·1
20 12 20	+16·0	−0·8	−18·8	−3·6		−2·8	+2·6	−0·2
21 13 3	+17·6	−0·8	−18·1	−1·3		+1·3	+0·9	+2·2
23 14 27	+ 8·0	−0·5	−10·7	−3·2		+1·0	−2·0	−1·0
24 15 9	+ 5·6	−0·5	− 6·2	−1·1		+2·5	−2·8	−0·3
26 16 39	+ 4·3	−0·4	− 3·9	0·0		+1·3	−2·8	−1·5
27 17 28	+ 3·8	−0·4	− 5·7	−2·3		+3·3	−3·1	+0·2
30 20 3	+ 9·6	−0·6	−11·9	−2·9		+7·7	−4·3	+3·4
Sept. 11 5 59	+15·6	−0·9	−17·2	−2·5		+0·7	+2·4	+3·1
12 6 58	+10·5	−0·7	−13·8	−4·0		−4·6	+2·7	−1·9
13 7 53	+ 9·6	−0·7	−12·4	−3·5		−2·1	+3·3	+1·2
14 8 44	+ 8·1	−0·5	−12·2	−4·6		−4·9	+3·2	−1·7
16 10 17	+10·3	−0·6	−15·7	−6·0		+1·4	+1·8	+3·2
17 11 0	+16·9	−0·8	−18·3	−2·2		+0·5	+0·5	+1·0
18 11 42	+19·3	−0·8	−20·4	−1·9		−1·8	−0·9	−2·7
20 13 6	+20·4	−1·0	−18·7	+0·7		+4·3	−3·1	+1·2
21 13 49	+15·3	−0·8	−14·2	+0·3		+3·2	−3·5	−0·3
24 16 11	+ 4·1	−0·4	− 5·9	−2·2		+2·0	−3·1	−1·1
25 17 1	+ 2·9	−0·4	− 7·9	−5·4		+3·2	−3·5	−0·3

Approx. G.M.T. 1861.			B−O	Longitude. Corr. to B.	H−B	H−O	B−O	H.N.P.D. H−B	H−O
	d	h	m						
Sept. 26	17	53	+ 10ʺ7	− 0ʺ7	− 11ʺ4	− 1ʺ4	+ 4ʺ9	− 4ʺ3	+ 0ʺ6
28	19	35	+ 19·1	− 0·9	− 18·1	+ 0·1	+ 5·3	− 5·7	− 0·4
Oct. 9	4	51	+ 20·5	− 1·2	− 24·5	− 5·2	+ 1·7	+ 6·5	+ 8·2
11	6	41	+ 10·0	− 0·6	− 14·0	− 4·6	− 6·0	+ 6·2	+ 0·2
12	7	30	+ 9·1	− 0·5	− 12·0	− 3·4	− 5·3	+ 5·2	− 0·1
13	8	16	+ 5·1	− 0·4	− 11·5	− 6·8	− 3·2	+ 3·9	+ 0·7
14	8	59	+ 6·1	− 0·4	− 11·7	− 6·0	− 0·6	+ 2·0	+ 1·4
15	9	41	+ 9·1	− 0·6	− 12·8	− 4·3	+ 1·8	+ 0·2	+ 2·0
17	11	4	+ 12·8	− 0·7	− 16·7	− 4·6	+ 2·4	− 2·6	− 0·2
18	11	47	+ 17·3	− 0·8	− 18·4	− 1·9	+ 1·3	− 3·6	− 2·3
19	12	32	+ 21·1	− 1·0	− 18·8	+ 1·3	+ 4·4	− 3·9	+ 0·5
20	13	18	+ 17·6	− 0·9	− 17·1	− 0·4	+ 5·0	− 3·9	+ 1·1
21	14	7	+ 15·1	− 0·8	− 14·1	+ 0·2	+ 2·5	− 3·4	− 0·9
22	14	56	+ 11·3	− 0·7	− 11·2	− 0·6	+ 2·6	− 2·9	− 0·3
26	18	16	+ 18·7	− 0·9	− 18·3	− 0·5	+ 5·2	− 4·0	+ 1·2
27	19	5	+ 23·3	− 1·0	− 22·4	− 0·1	+ 5·8	− 3·9	+ 1·9
Nov. 7	4	34	+ 18·8	− 1·0	− 22·6	− 4·8	− 7·6	+ 8·7	+ 1·1
8	5	26	+ 12·1	− 0·6	− 17·8	− 6·3	− 11·5	+ 7·6	− 3·9
9	6	13	+ 10·4	− 0·5	− 15·3	− 5·4	− 6·9	+ 6·0	− 0·9
11	7	40	+ 7·9	− 0·5	− 13·2	− 5·8	− 1·3	+ 1·6	+ 0·3
15	10	29	+ 7·9	− 0·6	− 12·2	− 4·9	+ 4·2	− 3·8	+ 0·4
17	12	3	+ 14·6	− 0·8	− 16·9	− 2·2	+ 2·3	− 3·4	− 1·1
18	12	53	+ 18·0	− 0·9	− 16·8	+ 0·3	+ 3·4	− 2·8	+ 0·6
19	13	43	+ 15·2	− 0·8	− 16·1	− 1·7	+ 1·2	− 2·0	− 0·8
20	14	34	+ 12·4	− 0·7	− 14·2	− 2·5	+ 3·9	− 1·3	+ 2·6
22	16	12	+ 13·3	− 0·7	− 11·6	+ 1·0	+ 3·2	− 0·6	+ 2·6
23	17	0	+ 14·0	− 0·7	− 13·2	+ 0·1	+ 2·6	− 0·7	+ 1·9
24	17	47	+ 18·5	− 0·9	− 16·6	+ 1·0	+ 1·8	− 0·5	+ 1·3
Dec. 8	5	37	+ 8·1	− 0·5	− 13·2	− 5·6	− 0·6	+ 1·9	+ 1·3
9	6	19	+ 6·0	− 0·5	− 13·1	− 7·6	− 0·7	− 0·6	− 1·3
10	7	1	+ 7·5	− 0·5	− 13·6	− 6·6	+ 2·2	− 2·7	− 0·5
11	7	43	+ 6·1	− 0·5	− 13·5	− 7·9	+ 4·9	− 4·4	+ 0·5
14	9	59	+ 4·8	− 0·5	− 11·0	− 6·7	+ 4·3	− 5·4	− 1·1
17	12	30	+ 10·0	− 0·6	− 14·0	− 4·6	+ 6·5	− 2·7	+ 3·8
18	13	21	+ 13·5	− 0·7	− 14·7	− 1·9	+ 5·8	− 1·6	+ 4·2
19	14	10	+ 12·6	− 0·7	− 14·2	− 2·3	+ 3·0	− 0·5	+ 2·5
23	17	18	+ 17·0	− 0·9	− 13·2	+ 2·9	− 1·5	+ 1·5	0·0
24	18	6	+ 15·4	− 0·8	− 14·9	− 0·3	− 0·1	+ 2·4	+ 2·3
25	18	57	+ 18·9	− 1·0	− 14·6	+ 3·3	− 1·1	+ 3·5	+ 2·4
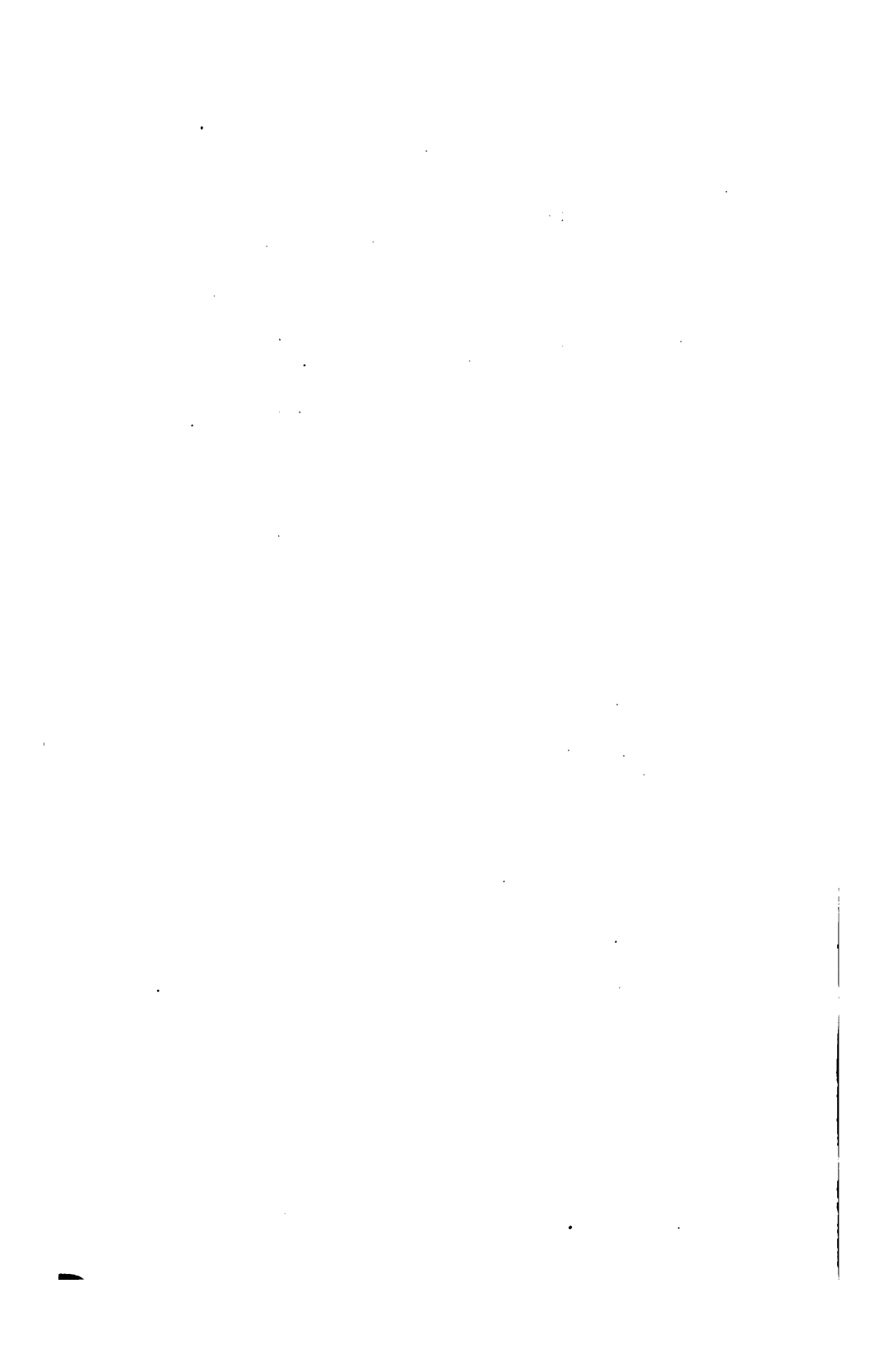
ERRORS OF

HANSEN'S LUNAR TABLES

IN

LONGITUDE AND ECLIPTIC NORTH POLAR DISTANCE

AS DEDUCED FROM OBSERVATIONS MADE WITH THE

ALTAZIMUTH

AT THE

ROYAL OBSERVATORY, GREENWICH

IN THE YEARS

1847-61

h

Errors of Hansen's Tables deduced from Observations with the Altazimuth.

Approx. G.M.T. 1847.			Longitude.				E.N.P.D.		
			B−0	Corr. to B.	H−B	H−0	B−0	H−B	H−0
d	h	m							
May 16	8	10	− 6·3	−0·3	+ 2·1	− 4·5	0·0	− 5·7	−5·7
19	9	4	+ 6·2	−0·3	− 3·4	+ 2·5	− 1·2	+ 1·6	+0·4
20	7	50	+ 6·6	−0·3	− 5·1	+ 1·2	− 2·1	+ 3·7	+1·6
21	6	18	+ 7·8	−0·3	− 7·3	+ 0·2	− 6·9	+ 5·8	−1·1
22	8	8	+14·0	−0·3	− 9·9	+ 3·8	−12·0	+ 7·8	−4·2
23	6	27	+15·2	−0·3	−11·0	+ 3·9	−11·9	+ 9·0	−2·9
24	12	16	+10·9	−0·3	−10·3	+ 0·3	−15·1	+10·1	−5·0
25	9	20	+11·4	−0·3	− 7·8	+ 3·3	−10·6	+10·0	−0·6
26	7	25	+ 6·5	−0·3	− 4·6	+ 1·6	− 8·6	+ 9·5	+0·9
27	8	9	+ 1·8	−0·3	− 1·9	− 0·4	− 8·9	+ 8·5	−0·4
28	8	38	+ 0·3	−0·3	− 1·3	− 1·3	−11·2	+ 7·0	−4·2
29	9	49	+ 2·4	−0·3	− 2·0	+ 0·1	− 3·7	+ 5·1	+1·4
30	10	35	+ 4·3	−0·3	− 3·8	+ 0·2	− 2·1	+ 3·2	+1·1
31	10	55	+ 6·3	−0·3	− 5·5	+ 0·5	+ 0·3	+ 1·5	+1·8
June 1	11	55	+ 8·2	−0·3	− 7·2	+ 0·7	+ 1·7	− 0·2	+1·5
2	12	25	+12·4	−0·3	− 8·8	+ 3·3	+ 7·3	− 1·4	+5·9
4	16	50	+16·7	−0·3	−11·7	+ 4·7	+11·4	− 4·8	+6·6
6	14	26	+ 4·7	−0·3	− 6·5	− 2·1	+ 8·9	− 7·7	+1·2
8	15	38	0·0	−0·3	+ 5·2	+ 4·9	+16·5	− 9·3	+7·2
15	8	49	+14·6	−0·3	− 5·7	+ 8·6	− 1·8	− 1·2	−3·0
17	9	0	+ 6·4	−0·3	− 7·1	− 1·0	− 4·7	+ 2·8	−1·9
18	8	38	+ 6·0	−0·3	− 6·9	− 1·2	− 3·9	+ 4·4	+0·5
19	7	55	+ 3·2	−0·3	− 7·0	− 4·1	− 7·8	+ 5·8	−2·0
20	11	31	+ 6·9	−0·3	− 6·8	− 0·2	−10·6	+ 7·3	−3·3
21	8	28	+ 6·5	−0·3	− 6·5	− 0·3	−11·5	+ 8·3	−3·2
22	7	20	+ 9·1	−0·3	− 5·6	+ 3·2	−10·1	+ 9·1	−1·0
23	6	40	+ 0·9	−0·3	− 4·3	− 3·7	− 9·8	+ 9·8	0·0
24	7	28	+ 9·0	−0·3	− 3·7	+ 5·0	− 6·2	+ 9·8	+3·6
25	7	10	+ 4·0	−0·3	− 3·7	0·0	− 8·7	+ 9·5	+0·8
26	9	38	+ 7·6	−0·3	− 5·0	+ 2·3	−11·1	+ 8·2	−2·9
27	8	44	+ 5·2	−0·3	− 6·8	− 1·9	− 8·5	+ 6·9	−1·6
28	10	10	+10·4	−0·3	− 8·6	+ 1·5	− 4·6	+ 5·0	+0·4
30	11	55	+22·4	−0·3	−10·7	+11·4	− 0·7	+ 1·3	+0·6
July 4	12	38	+12·6	−0·3	− 7·3	+ 5·0	+ 7·1	− 5·6	+1·5
5	13	25	+ 6·9	−0·3	− 4·4	+ 2·2	+ 9·1	− 6·9	+2·2
7	14	50	+ 7·2	−0·3	− 0·5	+ 6·4	+ 8·0	− 7·1	+0·9
8	14	55	+ 3·9	−0·3	− 0·1	+ 3·5	+ 7·7	− 6·1	+1·6
18	7	56	+10·4	−0·3	− 6·1	+ 4·0	− 3·8	+ 4·4	+0·6
21	7	50	+ 3·3	−0·3	− 5·0	− 2·0	− 8·1	+ 7·2	−0·9

Approx. G.M.T. 1847.			Longitude.				R.N.P.D.		
			B − O	Corr. to B.	H − B	H − O	B − O	H − B	H − O
	d	h	m							
July 22	6	48	+ 6ʺ·4	− 0ʺ·3	− 6ʺ·0	+ 0ʺ·1	− 4ʺ·8	+ 7ʺ·8	+ 3ʺ·0
23	8	10	+ 3·8	− 0·3	− 7·4	− 3·9	− 6·1	+ 8·1	+ 2·0
25	10	53	+ 10·2	− 0·3	− 10·6	− 0·7	− 7·8	+ 7·5	− 0·3
26	9	6	+ 14·2	− 0·3	− 12·5	+ 1·4	− 5·1	+ 6·4	+ 1·3
27	8	56	+ 11·2	− 0·3	− 13·8	− 2·9	− 5·1	+ 5·3	+ 0·2
28	11	34	+ 16·8	− 0·3	− 14·7	+ 1·8	+ 0·3	+ 3·6	+ 3·9
29	10	19	+ 15·4	− 0·3	− 14·1	+ 1·0	+ 0·4	+ 2·0	+ 2·4
30	10	51	+ 16·5	− 0·3	− 12·0	+ 4·2	+ 4·2	+ 0·2	+ 4·4
31	11	11	+ 10·6	− 0·3	− 8·8	+ 1·5	+ 2·7	− 1·3	+ 1·4
Aug. 1	11	55	+ 8·6	− 0·3	− 5·4	+ 2·9	+ 3·4	− 2·9	+ 0·5
2	16	0	+ 4·4	− 0·3	− 4·1	0·0	+ 7·4	− 3·9	+ 3·5
3	12	44	+ 6·1	− 0·3	− 4·2	+ 1·6	+ 5·0	− 3·9	+ 1·1
6	14	49	+ 4·6	− 0·3	− 5·5	− 1·2	+ 0·6	+ 0·2	+ 0·8
14	7	45	+ 15·9	− 0·3	− 14·3	+ 1·3	− 3·2	+ 3·5	+ 0·3
20	8	8	+ 5·0	− 0·3	− 10·7	− 6·0	− 1·8	+ 3·2	+ 1·4
21	6	36	+ 10·4	− 0·3	− 11·8	− 1·7	− 3·5	+ 3·2	− 0·3
23	9	27	+ 9·3	− 0·3	− 11·7	− 2·7	+ 0·9	+ 3·0	+ 3·9
25	8	35	+ 12·8	− 0·3	− 13·1	− 0·6	− 0·8	+ 1·5	+ 0·7
26	8	39	+ 14·2	− 0·3	− 13·9	0·0	− 4·6	+ 0·4	− 4·2
27	9	15	+ 13·6	− 0·3	− 13·1	+ 0·2	− 1·1	− 0·9	− 2·0
28	9	24	+ 13·8	− 0·3	− 10·6	+ 2·9	− 4·2	− 2·2	− 6·4
29	10	33	+ 6·0	− 0·3	− 7·6	− 1·9	0·0	− 3·2	− 3·2
31	11	29	+ 6·5	− 0·3	− 6·4	− 0·2	− 1·1	− 3·2	− 4·3
Sept. 1	12	11	+ 5·8	− 0·3	− 7·2	− 1·7	− 4·0	− 2·1	− 6·1
2	12	50	+ 4·2	− 0·3	− 7·4	− 3·5	− 4·1	− 0·4	− 4·5
3	16	28	+ 4·2	− 0·3	− 6·1	− 2·2	− 4·1	+ 2·0	− 2·1
4	14	45	+ 1·0	− 0·3	− 4·6	− 3·9	− 6·8	+ 3·6	− 3·2
5	16	45	+ 1·2	− 0·3	− 4·2	− 3·3	− 3·9	+ 4·9	+ 1·0
6	16	49	+ 2·2	− 0·3	− 5·7	− 3·8	− 2·4	+ 5·6	+ 3·2
14	6	58	+ 15·0	− 0·3	− 12·5	+ 2·2	0·0	+ 0·7	+ 0·7
16	7	3	+ 6·7	− 0·3	− 10·9	− 4·5	− 2·0	− 0·4	− 2·4
18	5	43	+ 11·6	− 0·3	− 11·5	− 0·2	+ 1·0	− 0·8	+ 0·2
20	10	40	+ 7·3	− 0·3	− 8·5	− 1·5	+ 0·9	− 1·2	− 0·3
21	14	6	+ 1·4	− 0·3	− 6·5	− 5·4	+ 7·0	− 1·7	+ 5·3
22	7	4	+ 5·0	− 0·3	− 5·9	− 1·2	+ 2·2	− 2·2	0·0
23	8	20	+ 5·7	− 0·3	− 6·2	− 0·8	+ 0·1	− 2·9	− 2·8
24	8	10	+ 12·3	− 0·3	− 7·5	+ 4·5	+ 4·8	− 3·9	+ 0·9
25	8	9	+ 12·0	− 0·3	− 8·9	+ 2·8	+ 0·9	− 4·8	− 3·9
26	8	19	+ 14·0	− 0·3	− 9·4	+ 4·3	− 1·1	− 5·1	− 6·2
27	9	15	+ 16·8	− 0·3	− 9·8	+ 6·7	+ 3·1	− 4·7	− 1·6
28	11	4	+ 18·4	− 0·3	− 10·3	+ 7·8	− 0·1	− 3·4	− 3·5
29	22	25	+ 13·1	− 0·3	− 10·1	+ 2·7	+ 3·7	− 1·0	+ 2·7

Approx. G.M.T. 1847.			Longitude.				E.N.P.D.		
			B−O	Corr. to B.	H−B	H−O	B−O	H−B	H−O
	d	h	m							

				B−O	Corr. to B.	H−B	H−O	B−O	H−B	H−O
Oct.	2	14	50	+ 11·1	− 0·3	− 6·4	+ 4·4	− 11·5	+ 4·0	− 7·5
	3	17	28	+ 4·7	− 0·3	− 4·2	+ 0·2	− 4·7	+ 5·3	+ 0·6
	5	16	13	+ 3·4	− 0·3	− 3·3	− 0·2	− 6·0	+ 5·9	− 0·1
	6	17	50	+ 7·2	− 0·3	− 5·2	+ 1·7	− 5·4	+ 5·7	+ 0·3
	13	5	20	+ 22·1	− 0·3	− 17·4	+ 4·4	+ 1·5	− 0·8	+ 0·7
	17	4	54	+ 1·9	− 0·3	− 7·6	− 6·0	− 0·4	− 1·6	− 2·0
	18	7	31	+ 7·9	− 0·3	− 7·1	+ 0·5	+ 1·4	− 1·8	− 0·4
	19	5	48	+ 3·2	− 0·3	− 5·8	− 2·9	+ 0·7	− 2·1	− 1·4
	20	5	53	+ 1·5	− 0·3	− 3·7	− 2·5	+ 1·1	− 2·8	− 1·7
	21	6	10	+ 2·6	− 0·3	− 1·5	+ 0·8	+ 3·5	− 3·5	0·0
	22	6	44	+ 2·2	− 0·3	− 1·2	+ 0·7	+ 3·3	− 4·3	− 1·0
	23	16	51	+ 6·5	− 0·3	− 4·2	+ 2·0	+ 6·7	− 5·0	+ 1·7
	24	7	15	+ 8·2	− 0·3	− 6·1	+ 1·8	+ 2·3	− 5·1	− 2·8
	25	8	5	+ 12·6	− 0·3	− 8·6	+ 3·7	+ 1·6	− 4·2	− 2·6
	26	8	20	+ 13·1	− 0·3	− 9·8	+ 3·0	− 4·9	− 2·7	− 7·6
	28	18	5	+ 13·6	− 0·3	− 8·3	+ 5·0	− 1·5	+ 1·7	+ 0·2
	29	13	49	+ 14·4	− 0·3	− 7·6	+ 6·5	− 5·7	+ 3·3	− 2·4
	30	18	3	+ 12·0	− 0·3	− 6·7	+ 5·0	− 5·4	+ 5·1	− 0·3
	31	22	58	+ 8·2	− 0·3	− 5·8	+ 2·1	− 3·5	+ 6·5	+ 3·0
Nov.	1	14	4	+ 7·2	− 0·3	− 5·4	+ 1·5	− 11·9	+ 7·0	− 4·9
	10	4	49	+ 23·8	− 0·3	− 21·2	+ 2·3	+ 0·2	+ 0·3	+ 0·5
	15	6	54	+ 7·6	− 0·3	− 6·5	+ 0·8	+ 1·9	0·0	+ 1·9
	16	5	24	+ 5·9	− 0·3	− 7·3	− 1·7	+ 4·2	− 0·7	+ 3·5
	17	8	30	+ 6·2	− 0·3	− 7·2	− 1·3	+ 1·1	− 1·9	− 0·8
	18	4	26	+ 6·0	− 0·3	− 5·9	− 0·2	− 1·0	− 2·7	− 3·7
	19	4	43	+ 1·2	− 0·3	− 4·0	− 3·1	+ 5·0	− 3·5	+ 1·5
	21	7	7	+ 3·7	− 0·3	− 4·5	− 1·1	+ 5·9	− 4·0	+ 1·9
	22	17	44	+ 5·1	− 0·3	− 6·2	− 1·4	+ 3·3	− 2·7	+ 0·6
	23	7	21	+ 4·3	− 0·3	− 6·7	− 2·7	− 4·3	− 1·9	− 6·2
	24	7	38	− 0·8	− 0·3	− 7·3	− 8·4	− 1·5	− 0·5	− 2·0
	27	13	17	+ 8·0	− 0·3	− 4·4	+ 3·3	− 4·5	+ 4·6	+ 0·1
	28	14	51	+ 4·7	− 0·3	− 4·3	+ 0·1	− 7·0	+ 5·9	− 1·1
	29	13	23	+ 6·3	− 0·3	− 4·5	+ 1·5	− 1·5	+ 7·0	+ 5·5
	30	17	16	+ 3·7	− 0·3	− 4·8	− 1·4	− 9·7	+ 8·0	− 1·7
Dec.	1	16	31	+ 8·8	− 0·3	− 4·7	+ 3·8	− 4·7	+ 8·8	+ 4·1
	3	17	19	+ 1·6	− 0·3	− 3·4	− 2·1	− 10·6	+ 7·3	− 3·3
	11	5	49	+ 15·6	− 0·3	− 13·0	+ 2·3	+ 2·3	+ 1·6	+ 3·9
	12	6	34	+ 13·1	− 0·3	− 9·4	+ 3·4	+ 2·9	+ 1·5	+ 4·4
	13	3	41	+ 9·0	− 0·3	− 7·8	+ 0·9	+ 1·5	+ 1·2	+ 2·7
	14	7	55	+ 8·6	− 0·3	− 7·5	+ 0·8	+ 4·4	+ 0·3	+ 4·7
	16	4	35	+ 6·5	− 0·3	− 8·9	− 2·7	+ 3·4	− 2·2	+ 1·2
	18	11	21	+ 6·1	− 0·3	− 8·8	− 3·0	+ 7·3	− 3·5	+ 3·8
	19	7	29	+ 2·8	− 0·3	− 8·4	− 5·9	+ 3·0	− 3·1	− 0·1
	23	14	38	− 3·2	− 0·3	− 5·3	− 8·8	− 1·1	+ 0·8	− 0·3
	27	15	20	0·0	− 0·3	− 3·1	− 3·4	− 1·9	+ 5·0	+ 3·1
	28	17	10	− 1·0	− 0·3	− 2·7	− 4·0	− 0·7	+ 5·8	+ 5·1

Errors of Hansen's Tables deduced

Approx. G.M.T. 1848		B–0	Longitude. Corr. to B.	H–B	H–0	R.N.P.D. B–0	H–B	H–0
	h m	"	"	"	"	"	"	"
Jan. 3	19 55	+ 7·7	−0·3	− 6·8	+0·6	− 5·3	+4·6	− 0·7
12	4 24	+ 8·5	−0·3	− 8·8	−0·6	+ 3·7	−2·4	+ 1·3
13	10 16	+13·1	−0·3	− 9·0	+3·8	+14·1	−3·2	+10·9
15	4 4	+12·5	−0·3	−11·5	+0·7	+ 2·6	−3·1	− 0·5
16	4 45	+11·8	−0·3	−11·9	−0·4	+ 1·9	−1·9	0·0
18	4 54	+12·3	−0·3	− 7·5	+4·5	+ 0·2	+0·6	+ 0·8
20	8 50	+ 4·8	−0·3	− 4·3	+0·2	− 1·6	+2·0	+ 0·4
23	12 11	+ 4·2	−0·3	− 5·0	−1·1	− 2·9	+3·2	+ 0·3
26	13 58	+ 0·4	−0·3	− 1·7	−1·6	− 3·8	+4·3	+ 0·5
31	19 41	+ 5·0	−0·3	− 1·9	+2·8	− 3·6	+3·3	− 0·3
Feb. 8	5 35	+18·8	−0·3	−19·4	−0·9	+10·1	−3·8	+ 6·3
9	5 20	+17·2	−0·3	−14·9	+2·0	+ 8·0	−4·4	+ 3·6
11	6 47	+ 9·5	−0·3	−10·9	−1·7	+ 4·0	−3·9	+ 0·1
12	5 33	+ 9·5	−0·3	−11·9	−2·7	+ 3·7	−2·7	+ 1·0
14	9 27	+15·0	−0·3	−11·4	+3·3	+ 0·3	+2·0	+ 2·3
15	7 1	+10·9	−0·3	− 8·6	+2·0	− 3·5	+3·6	+ 0·1
16	6 11	+ 5·0	−0·3	− 5·6	−0·9	− 3·7	+4·8	+ 1·1
17	6 15	+ 5·6	−0·3	− 3·4	+1·9	− 7·1	+5·3	− 1·8
18	6 33	+ 3·9	−0·3	− 3·2	+0·4	− 6·2	+5·6	− 0·6
19	7 38	+ 6·7	−0·3	− 4·2	+2·2	− 8·0	+5·5	− 2·5
20	8 46	+ 2·4	−0·3	− 4·8	−2·7	− 5·1	+5·2	+ 0·1
22	10 35	+ 5·3	−0·3	− 3·1	+1·9	− 7·1	+4·2	− 2·9
23	13 58	+ 6·5	−0·3	− 1·9	+4·3	− 1·4	+3·9	+ 2·5
24	15 53	+ 7·0	−0·3	− 1·7	+5·0	− 7·4	+3·5	− 3·9
25	14 25	+10·5	−0·3	− 2·1	+8·1	− 3·8	+3·4	− 0·4
27	16 35	+ 3·1	−0·3	− 1·3	+1·5	+ 3·7	₹3·0	+ 6·7
28	16 43	+ 1·9	−0·3	+ 0·6	+2·2	− 1·8	+2·8	+ 1·0
Mar. 7	7 6	+18·6	−0·3	−22·7	−4·4	+ 4·6	−3·9	+ 0·7
9	10 43	+18·6	−0·3	−14·9	+3·4	+10·7	−3·7	+ 7·0
10	6 19	+14·0	−0·3	−11·7	+2·0	+ 3·7	−2·8	+ 0·9
11	4 13	+ 9·0	−0·3	− 9·9	−1·2	− 0·7	−1·4	− 2·1
12	12 35	+ 7·8	−0·3	− 9·4	−1·9	+ 2·8	+1·3	+ 4·1
14	6 18	+10·9	−0·3	− 8·6	+2·0	− 7·7	+5·0	− 2·7
17	20 23	+ 5·4	−0·3	− 3·3	+1·8	− 7·9	+8·0	+ 0·1
18	6 44	+ 3·8	−0·3	− 3·3	+0·2	− 7·9	+7·7	− 0·2
19	7 15	+ 7·7	−0·3	− 3·9	+3·5	− 9·4	+7·0	− 2·4
20	8 26	+ 5·0	−0·3	− 4·6	+0·1	− 6·7	+6·1	− 0·6
21	9 26	+ 5·2	−0·3	− 5·2	−0·3	− 6·7	+5·1	− 1·6
24	16 40	+ 8·8	−0·3	− 4·6	+3·9	− 2·6	+2·3	− 0·3

Approx. G.M.T. 1848.			Longitude.				R.N.P.D.		
			B−O	Corr. to B.	H−B	H−O	B−O	H−B	H−O
d	h	m							
Mar. 27	19	33	+ 5"4	−0"3	− 1"1	+ 4"0	− 4"2	+ 1"5	− 2"7
29	18	5	− 5·3	−0·3	+ 4·6	− 1·0	+ 7·8	+ 1·7	+ 9·5
31	17	20	− 8·3	−0·3	+ 8·6	0·0	+ 0·5	+ 1·4	+ 1·9
Apr. 6	7	6	+11·1	−0·3	−13·0	− 2·2	− 1·6	−2·9	−4·5
10	8	3	+ 5·7	−0·3	− 3·7	+ 1·7	− 2·5	+3·1	+0·6
11	6	44	+ 6·4	−0·3	− 5·5	+ 0·6	− 2·2	+5·0	+2·8
12	8	53	+ 7·1	−0·3	− 7·1	− 0·3	− 9·7	+6·8	−2·9
14	7	4	+12·6	−0·3	− 6·7	+ 5·6	− 9·5	+8·4	−1·1
17	8	24	+13·8	−0·3	− 3·5	+10·0	−10·8	+6·3	−4·5
18	11	4	+13·6	−0·3	− 4·4	+ 8·9	− 4·6	+4·8	+0·2
19	8	59	+ 8·2	−0·3	− 5·5	+ 2·4	− 5·6	+3·2	−2·4
25	15	25	+ 6·2	−0·3	− 5·1	+ 0·8	+ 4·1	−1·6	+2·5
26	15	34	+ 1·6	−0·3	− 3·0	− 1·7	+ 3·5	−1·6	+1·9
28	16	20	− 0·6	−0·3	+ 5·7	+ 4·8	+ 6·3	−2·6	+3·7
May 4	7	53	+ 6·6	−0·3	− 2·7	+ 3·6	+ 6·5	−4·3	+2·2
5	7	55	+ 4·5	−0·3	− 4·4	− 0·2	+ 6·5	−3·2	+3·3
6	7	49	+ 5·0	−0·3	− 3·0	+ 1·7	+ 4·5	−1·9	+2·6
7	7	59	+ 5·8	−0·3	− 0·9	+ 4·6	+ 4·0	−0·3	+3·7
8	7	21	+ 1·5	−0·3	− 0·4	+ 0·8	− 2·1	+1·5	−0·6
9	8	30	+ 6·9	−0·3	− 2·2	+ 4·4	− 1·5	+3·5	+2·0
10	3	5	+ 7·2	−0·3	− 4·6	+ 2·3	− 5·2	+5·1	−0·1
11	4	53	+ 6·7	−0·3	− 7·6	− 1·2	− 8·2	+6·9	−1·3
12	6	21	+11·1	−0·3	− 9·1	+ 1·7	− 8·3	+8·0	−0·3
13	5	38	+ 9·6	−0·3	− 8·6	+ 0·7	−10·7	+8·3	−2·4
14	6	44	+ 8·3	−0·3	− 6·6	+ 1·4	−11·1	+7·9	−3·2
15	7	19	+ 6·1	−0·3	− 4·1	+ 1·7	− 7·8	+6·6	−1·2
16	8	10	+ 6·3	−0·3	− 2·3	+ 3·7	− 6·4	+5·0	−1·4
17	8	20	+ 2·2	−0·3	− 1·8	+ 0·1	− 1·5	+3·3	+1·8
18	9	19	+ 6·7	−0·3	− 2·6	+ 3·8	− 3·4	+1·2	−2·2
19	11	44	+ 5·2	−0·3	− 4·4	+ 0·5	+ 3·3	−0·4	+2·9
20	11	25	+ 8·2	−0·3	− 6·0	+ 1·9	+ 0·7	−1·7	−1·0
22	15	40	+ 9·1	−0·3	− 8·8	0·0	+ 8·3	−3·6	+4·7
23	14	0	+ 5·1	−0·3	− 9·7	− 4·9	+ 5·2	−4·1	+1·1
24	14	1	+15·8	−0·3	−10·1	+ 5·4	+ 4·3	−5·1	−0·8
25	14	32	+ 8·6	−0·3	− 8·8	− 0·5	+ 8·1	−6·0	+2·1
27	15	5	− 1·3	−0·3	+ 1·4	− 0·2	+ 6·7	−7·4	−0·7
28	15	44	− 7·7	−0·3	+ 8·4	+ 0·4	+ 9·9	−7·7	+2·2
June 3	8	30	+ 6·7	−0·3	− 5·3	+ 1·1	+ 6·4	−3·5	+2·9
4	8	25	+14·7	−0·3	− 6·6	+ 7·8	+ 5·2	−2·0	+3·2
5	8	41	+10·1	−0·3	− 6·5	+ 3·3	+ 1·8	−0·3	+1·5
6	8	13	+ 8·6	−0·3	− 6·3	+ 2·0	0·0	+1·3	+1·3

Approx. G.M.T. 1848			Longitude.				R.N.P.D.		
			B−O	Corr. to B.	H−B	H−O	B−O	H−B	H−O
d	h	m							
June 7	7	48	+ 8.2	−0.3	− 6.5	+1.4	−4.5	+3.2	−1.3
8	8	56	+12.2	−0.3	− 7.4	+4.5	−2.6	+4.9	+0.3
11	5	59	+ 9.3	−0.3	− 8.8	+0.2	−9.7	+7.0	−2.7
12	10	15	+ 7.5	−0.3	− 6.8	+0.4	−4.9	+6.0	+1.1
13	7	5	+ 6.7	−0.3	− 4.7	+1.7	−6.9	+4.9	−2.0
14	7	35	− 1.0	−0.3	− 2.3	+3.6	−4.9	+3.5	−1.4
15	8	55	+ 4.8	−0.3	− 1.1	+3.4	−4.7	+2.2	−2.5
16	9	54	+ 5.4	−0.3	− 1.5	+3.6	−1.9	+1.1	−0.8
20	13	24	+ 9.9	−0.3	− 9.3	+0.3	+5.5	−2.7	+2.8
21	14	10	+13.8	−0.3	−11.2	+2.3	+5.5	−4.0	+1.5
July 5	8	18	+17.1	−0.3	−11.5	+5.3	−1.4	+2.7	+1.3
6	8	34	+ 9.3	−0.3	− 8.7	+0.3	−0.5	+3.1	+2.6
7	9	38	+10.3	−0.3	− 6.6	+3.4	−2.2	+3.7	+1.5
8	8	54	+ 2.3	−0.3	− 5.8	−3.8	−2.0	+4.0	+2.0
9	8	44	+ 2.4	−0.3	− 6.1	−4.0	−3.3	+3.7	+0.4
10	8	38	+12.5	−0.3	− 6.4	+5.8	−2.3	+2.9	+0.6
11	6	29	+ 3.3	−0.3	− 6.2	−3.2	−3.3	+2.6	−0.7
12	7	23	+ 3.8	−0.3	− 5.2	−1.7	−3.0	+1.9	−1.1
13	7	48	+ 5.6	−0.3	− 4.8	+0.5	−1.6	+1.5	−0.1
14	8	55	+ 4.6	−0.3	− 5.1	−0.8	−2.0	+1.3	−0.7
15	8	38	+11.5	−0.3	− 6.2	+5.0	+0.2	+1.0	+1.2
16	9	48	+ 8.3	−0.3	− 7.8	+0.2	−0.7	+1.0	+0.3
17	10	30	+ 9.8	−0.3	− 8.6	+0.9	+0.8	+0.4	+1.2
18	9	56	+11.2	−0.3	− 8.8	+2.1	−3.1	−0.2	−3.3
20	11	6	+11.7	−0.3	− 9.2	+2.2	−0.3	−2.6	−2.9
21	15	13	+12.2	−0.3	−10.2	+1.7	+5.5	−3.7	+1.8
22	12	21	+13.4	−0.3	−10.7	+2.4	−2.2	−4.2	−6.4
24	13	20	+10.8	−0.3	− 8.5	+2.0	−2.0	−2.2	−4.2
26	16	34	+ 7.8	−0.3	− 5.1	+2.4	−4.8	+1.8	−3.0
Aug. 2	7	55	+18.1	−0.3	−17.1	+0.7	+2.2	+5.4	+7.6
4	7	16	+ 9.6	−0.3	− 7.9	+1.4	+1.5	+3.0	+4.5
5	9	0	+ 6.4	−0.3	− 4.4	+1.7	−0.4	+1.8	+1.4
6	8	33	+ 3.3	−0.3	− 3.1	−0.1	+0.6	+0.9	+1.5
7	8	2	+ 0.3	−0.3	− 3.1	−3.1	+0.7	+0.2	+0.9
8	10	2	+ 0.6	−0.3	− 3.9	−3.6	+6.7	−0.5	+6.2
9	6	21	+ 3.7	−0.3	− 4.5	−1.1	−0.5	−0.9	−1.4
10	9	29	+ 7.1	−0.3	− 5.2	+1.6	+4.1	−0.8	+3.3
12	9	20	+ 5.6	−0.3	− 8.2	−2.9	+0.1	−0.4	−0.3
15	10	8	+12.3	−0.3	−10.2	+1.8	+0.5	−0.4	+0.1
16	9	59	+13.8	−0.3	− 8.8	+4.7	+3.9	−0.7	+3.2
17	10	45	+10.9	−0.3	− 7.8	+2.8	+1.2	−1.6	−0.4
18	10	41	+10.0	−0.3	− 7.4	+2.3	−0.5	−2.0	−2.5

Approx. G.M.T. 1848.			B−O	Longitude. Corr. to B.	H−B	H−O	E.N.P.D. B−O	H−B	H−O
	d	h m							
Aug. 19	11	19	+11″·1	−0″·3	− 8″·2	+ 2″·6	− 0″·3	−2·5	−2·8
20	13	9	+12·3	−0·3	− 9·4	+ 2·6	+ 1·5	−1·7	−0·2
21	11	55	+10·7	−0·3	−10·2	+ 0·2	− 4·4	−0·5	−4·9
22	12	23	+13·4	−0·3	−10·7	+ 2·4	− 9·4	+1·5	−7·9
24	14	59	+11·0	−0·3	−10·1	+ 0·6	−10·8	+5·8	−5·0
Sept. 3	7	0	+ 9·5	−0·3	− 4·9	+ 4·3	− 1·0	+0·1	−0·9
4	7	16	+ 4·7	−0·3	− 2·8	+ 1·6	+ 2·8	−1·2	+1·6
6	7	25	+ 6·9	−0·3	− 2·2	+ 4·4	+ 4·0	−2·4	+1·6
8	8	44	+ 6·8	−0·3	− 3·3	+ 3·2	+ 6·1	−2·7	+3·4
9	6	33	+ 9·7	−0·3	− 3·6	+ 5·8	+ 1·2	−2·7	−1·5
11	9	59	+ 8·1	−0·3	− 5·2	+ 2·6	+ 3·0	−2·2	+0·8
12	7	46	+19·5	−0·3	− 6·2	+13·0	+ 3·0	−2·2	+0·8
13	14	25	+ 8·6	−0·3	− 7·9	+ 0·4	+ 7·7	−2·0	+5·7
14	9	13	+11·5	−0·3	− 8·9	+ 2·3	+ 3·1	−2·4	+0·7
15	10	41	+ 7·2	−0·3	− 9·8	− 2·9	− 2·7	−2·2	−4·9
16	9	32	+12·2	−0·3	−10·2	+ 1·7	+ 0·8	−1·8	−1·0
17	11	1	+12·8	−0·3	−10·4	+ 2·1	− 3·3	−1·4	−4·7
18	10	41	+14·3	−0·3	−10·8	+ 3·2	− 2·3	+0·1	−2·2
19	11	38	+15·0	−0·3	−11·2	+ 3·5	− 5·4	+1·6	−3·8
20	13	6	+ 9·9	−0·3	−11·2	− 1·6	− 5·4	+3·3	−2·1
21	14	10	+10·8	−0·3	−10·3	+ 0·2	− 9·8	+5·2	−4·6
22	14	54	+ 7·9	−0·3	− 8·7	− 1·1	−14·4	+6·8	−7·6
Oct. 3	5	25	+ 5·8	−0·3	− 6·6	− 1·1	+ 8·0	−3·5	+4·5
5	7	10	+ 5·4	−0·3	− 3·8	+ 1·3	+ 4·9	−4·2	+0·7
6	7	39	− 2·9	−0·3	− 3·6	− 6·8	+ 4·3	−4·3	0·0
7	8	31	+ 3·4	−0·3	− 3·3	− 0·2	− 0·8	−4·5	−5·3
8	6	3	+ 3·4	−0·3	− 2·2	+ 0·9	+ 3·8	−4·5	+0·7
9	7	58	+ 0·2	−0·3	− 0·9	− 1·0	+ 2·4	−4·5	−2·1
10	7	41	+ 2·0	−0·3	− 0·5	+ 1·2	+ 2·6	−4·3	−1·7
11	6	45	+ 1·8	−0·3	− 1·8	− 0·3	− 0·3	−4·1	−4·4
12	7	18	+ 9·9	−0·3	− 5·0	+ 4·6	+ 2·7	−3·8	−1·1
13	11	8	+12·4	−0·3	− 8·9	+ 3·2	+ 0·7	−2·5	−1·8
14	7	38	+15·2	−0·3	−10·6	+ 4·3	− 2·0	−1·5	−3·5
15	9	13	+13·6	−0·3	−10·7	+ 2·6	− 5·5	−0·1	−5·6
16	9	43	+14·4	−0·3	−10·4	+ 3·7	− 4·3	+1·6	−2·7
18	15	10	+ 9·2	−0·3	−10·6	− 1·7	− 6·6	+5·6	−1·0
19	15	42	+15·1	−0·3	−10·2	+ 4·6	− 8·4	+7·4	−1·0
21	14	55	+ 5·5	−0·3	− 5·7	− 0·5	−11·6	+9·0	−2·6
22	16	20	− 1·0	−0·3	− 3·8	− 5·1	− 9·6	+9·1	−0·5
30	5	5	+21·3	−0·3	−20·3	+ 0·7	+ 2·1	−2·8	−0·7

Errors of Hansen's Tables deduced

Approx. G.M.T. 1848.			Longitude.				E.N.P.D.		
d	h	m	B−O	Corr. to B.	H−B	H−O	B−O	H−B	H−O
Nov. 3	7	8	+11·0	−0·3	− 8·4	+2·3	+ 4·9	− 4·1	+0·8
4	7	15	+ 8·3	−0·3	− 8·6	−0·6	+ 5·8	− 4·3	+1·5
5	7	53	+11·9	−0·3	− 9·0	+2·6	+ 6·8	− 5·0	+1·8
6	9	34	+11·1	−0·3	− 8·5	+2·3	+ 7·5	− 5·4	+2·1
7	5	0	+ 5·9	−0·3	− 7·1	−1·5	+ 7·6	− 5·5	+2·1
8	6	42	+ 2·8	−0·3	− 5·8	−3·3	+ 4·6	− 5·0	−0·4
9	5	3	+ 8·2	−0·3	− 6·0	+1·9	+ 4·8	− 4·1	+0·7
10	6	3	+ 7·4	−0·3	− 7·2	−0·1	+ 0·8	− 2·7	−1·9
11	9	56	+10·6	−0·3	− 8·6	+1·7	− 1·0	− 0·9	−1·9
12	11	10	+14·8	−0·3	− 8·0	+6·5	− 4·7	+ 0·7	−4·0
13	8	45	+10·3	−0·3	− 6·5	+3·5	− 9·5	+ 2·3	−7·2
14	9	19	+ 8·8	−0·3	− 5·1	+3·4	− 8·8	+ 4·3	−4·5
15	11	28	+11·5	−0·3	− 4·7	+6·5	− 9·9	+ 6·2	−3·7
16	18	12	+14·0	−0·3	− 5·7	+8·0	−12·0	+ 8·6	−3·4
17	15	50	+12·1	−0·3	− 6·0	+5·8	−10·3	+ 9·9	−0·4
18	14	49	+10·5	−0·3	− 5·6	+4·6	−12·7	+10·8	−1·9
20	17	48	+11·7	−0·3	− 3·4	+8·0	−14·6	+10·1	−4·5
Dec. 2	4	20	+ 8·9	−0·3	−10·8	−2·2	+ 1·7	− 0·7	+1·0
3	5	19	+10·2	−0·3	−11·2	−1·3	+ 3·4	− 1·7	+1·7
4	5	45	+14·2	−0·3	−13·2	+0·7	+ 2·8	− 2·4	+0·4
5	3	23	+12·7	−0·3	−15·0	−2·6	+ 1·6	− 3·1	−1·5
6	6	41	+19·3	−0·3	−15·8	+3·2	+ 5·4	− 3·2	+2·2
8	7	28	+15·7	−0·3	−13·0	+2·4	− 2·5	− 1·1	−3·6
9	5	18	+13·1	−0·3	−11·7	+1·1	− 2·9	+ 0·2	−2·7
10	6	3	+ 5·1	−0·3	−10·1	−5·3	− 1·5	+ 1·3	−0·2
11	8	15	+ 6·8	−0·3	− 8·2	−1·7	− 3·2	+ 2·5	−0·7
12	7	56	+ 4·9	−0·3	− 5·3	−0·7	− 3·8	+ 2·8	−1·0
13	8	38	+ 2·2	−0·3	− 2·9	−1·0	− 3·7	+ 4·3	+0·6
14	10	38	+ 4·6	−0·3	− 1·5	+2·8	− 3·3	+ 5·5	+2·2
16	20	29	+11·2	−0·3	− 2·7	+8·2	− 7·7	+ 7·7	0·0
17	16	16	+ 7·6	−0·3	− 3·4	+3·9	−10·4	+ 7·7	−2·7
18	15	58	+13·2	−0·3	− 4·2	+8·7	−12·0	+ 7·5	−4·5
20	17	51	+ 9·5	−0·3	− 3·8	+5·4	− 7·6	+ 4·8	−2·8
21	18	8	+ 5·6	−0·3	− 3·2	+2·1	− 5·1	+ 3·2	−1·9
22	18	50	+ 9·2	−0·3	− 3·6	+5·3	− 4·5	+ 2·0	−2·5
23	19	18	+ 9·6	−0·3	− 5·5	+3·8	− 2·0	+ 1·2	−0·8
28	5	28	+18·0	−0·3	−16·2	+1·5	+ 4·9	+ 1·4	+6·3

Approx. G.M.T. 1849.			Longitude				E.N.P.D.		
			B—O	Corr. to B.	H—B	H—O	B—O	H—B	H—O
d	h	m							
Jan. 2	5	6	+ 11·5	− 0·3	− 16·1	+ 1·1	+ 0·1	+ 0·2	+ 0·3
3	4	59	+ 5·3	− 0·3	− 13·4	− 8·4	− 2·8	0·0	− 2·8
5	10	33	+ 10·4	− 0·3	− 15·2	− 5·1	− 1·8	+ 1·7	− 0·1
6	4	44	+ 7·0	− 0·3	− 14·6	− 7·9	− 4·3	+ 2·3	− 2·0
8	11	9	+ 4·8	− 0·3	− 12·7	− 8·2	− 1·9	+ 4·3	+ 2·4
9	15	59	+ 10·1	− 0·3	− 12·2	− 2·4	− 0·8	+ 4·7	+ 3·9
10	8	59	+ 6·5	− 0·3	− 11·4	− 5·2	− 14·1	+ 4·6	− 9·5
11	15	44	+ 7·5	− 0·3	− 8·8	− 1·6	− 3·3	+ 4·5	+ 1·2
14	12	38	+ 3·7	− 0·3	− 5·2	− 1·8	− 3·5	+ 4·0	+ 0·5
15	17	40	+ 8·4	− 0·3	− 5·6	+ 2·5	− 6·5	+ 3·0	− 3·5
16	16	1	+ 10·7	− 0·3	− 5·9	+ 4·5	− 6·5	+ 2·1	− 4·4
17	16	26	+ 9·6	− 0·3	− 5·7	+ 3·6	− 1·3	+ 1·0	− 0·3
26	4	55	+ 9·6	− 0·3	− 13·2	− 3·9	+ 1·1	+ 0·1	+ 1·2
28	4	46	+ 3·6	− 0·3	− 7·8	− 4·5	+ 0·9	0·0	+ 0·9
29	7	39	+ 1·8	− 0·3	− 5·5	− 4·0	+ 3·5	− 0·2	+ 3·3
31	3	51	+ 5·6	− 0·3	− 7·3	− 2·0	− 0·5	+ 0·2	− 0·3
Feb. 1	5	40	− 1·5	− 0·3	− 10·0	− 11·8	− 4·3	+ 1·0	− 3·3
2	9	59	+ 7·3	− 0·3	− 12·6	− 5·6	− 0·6	+ 2·8	+ 2·2
4	9	48	+ 16·5	− 0·3	− 14·0	+ 2·2	− 3·6	+ 5·7	+ 2·1
8	8	45	+ 9·4	− 0·3	− 12·6	− 3·5	− 10·9	+ 6·5	− 4·4
9	11	48	+ 8·6	− 0·3	− 11·6	− 3·3	− 3·1	+ 5·7	+ 2·6
10	10	58	+ 8·3	− 0·3	− 10·5	− 2·5	− 5·0	+ 4·6	− 0·4
11	11	35	+ 10·4	− 0·3	− 9·2	+ 0·9	− 8·6	+ 3·5	− 5·1
12	12	24	+ 7·1	− 0·3	− 8·2	− 1·4	− 6·2	+ 2·1	− 4·1
13	15	3	+ 9·3	− 0·3	− 7·7	+ 1·3	− 3·7	+ 0·7	− 3·0
16	16	50	+ 2·8	− 0·3	− 3·7	− 1·2	+ 0·9	− 2·1	− 1·2
17	17	31	+ 1·8	− 0·3	− 0·5	+ 1·0	− 2·1	− 2·0	− 4·1
25	5	43	+ 4·6	− 0·3	− 11·2	− 6·9	+ 1·8	− 0·9	+ 0·9
26	5	41	+ 4·2	− 0·3	− 10·6	− 6·7	+ 2·8	− 1·0	+ 1·8
27	5	59	+ 4·8	− 0·3	− 9·4	− 4·9	+ 1·1	− 1·0	+ 0·1
28	10	1	+ 8·6	− 0·3	− 8·3	0·0	+ 10·0	− 0·6	+ 9·4
Mar. 1	4	42	+ 2·4	− 0·3	− 9·2	− 7·1	− 0·6	+ 0·2	− 0·4
2	4	46	+ 2·5	− 0·3	− 11·1	− 8·9	− 3·6	+ 1·7	− 1·9
3	6	59	+ 9·6	− 0·3	− 13·8	− 4·5	− 3·2	+ 3·9	+ 0·7
4	7	6	+ 8·4	− 0·3	− 15·7	− 7·6	− 5·6	+ 6·0	+ 0·4
5	10	5	+ 12·9	− 0·3	− 15·4	− 2·8	− 8·5	+ 7·8	− 0·7
6	7	3	+ 8·1	− 0·3	− 13·4	− 5·6	− 10·0	+ 8·5	− 1·5
8	7	28	+ 8·1	− 0·3	− 8·2	− 0·4	− 11·0	+ 8·2	− 2·8
9	8	33	+ 4·1	− 0·3	− 7·1	− 3·3	− 10·6	+ 6·9	− 3·7

Approx. G.M.T. 1849.			Longitude.				E.N.P.D.		
d	h	m	B−O	Corr. to B.	H−B	H−O	B−O	H−B	H−O
Mar. 10	9	15	+ 4.1	−0.3	− 7.1	− 3.3	− 8.7	+5.3	−3.4
16	15	18	+ 6.1	−0.3	− 5.1	+ 0.7	− 0.3	−2.4	−2.7
17	16	55	+ 5.4	−0.3	− 2.5	+ 2.6	+ 2.8	−2.2	+0.6
29	7	31	+ 3.4	−0.3	− 7.9	− 4.8	− 0.8	+2.3	+1.5
30	7	49	+ 7.0	−0.3	− 7.6	− 0.9	0.0	+3.0	+3.0
31	8	3	+ 4.7	−0.3	− 9.8	− 5.4	− 3.1	+4.4	+1.3
April 1	7	59	+ 4.3	−0.3	−12.7	− 8.7	− 4.5	+6.1	+1.6
2	9	2	+ 8.7	−0.3	−14.2	− 5.8	− 6.4	+7.7	+1.3
3	5	30	+ 9.8	−0.3	−13.4	− 3.9	− 9.3	+8.6	−0.7
5	7	54	+ 5.6	−0.3	− 6.8	− 1.5	− 7.9	+8.2	+0.3
6	7	40	− 1.2	−0.3	− 4.7	− 6.2	− 7.0	+6.8	−0.2
7	7	43	+ 0.6	−0.3	− 4.0	− 3.7	− 9.7	+4.9	−4.8
8	8	40	− 0.7	−0.3	− 4.2	− 5.2	− 2.7	+2.7	0.0
11	12	20	+ 6.4	−0.3	− 2.9	+ 3.2	− 1.0	−2.8	−3.8
13	16	13	+ 5.9	−0.3	− 3.4	+ 2.2	+ 6.4	−3.9	+2.5
14	16	0	+ 6.3	−0.3	− 3.7	+ 2.3	+ 4.8	−4.1	+0.7
15	15	38	+ 7.4	−0.3	− 2.8	+ 4.3	+ 5.5	−4.1	+1.4
17	17	4	− 1.5	−0.3	+ 5.6	+ 3.8	+ 4.2	−3.4	+0.8
26	8	35	+ 3.7	−0.3	− 7.7	− 4.3	0.0	+3.3	+3.3
28	7	21	+ 3.3	−0.3	− 4.0	− 1.0	− 4.9	+5.1	+0.2
30	8	18	+ 7.5	−0.3	− 6.7	+ 0.5	− 7.2	+7.8	+0.6
May 1	6	5	+ 6.6	−0.3	− 7.5	− 1.2	− 9.0	+8.6	−0.4
2	8	7	+ 4.4	−0.3	− 7.4	− 3.3	− 9.2	+8.7	−0.5
3	5	33	+ 2.4	−0.3	− 6.2	− 4.1	− 9.6	+8.0	−1.6
4	7	8	+ 4.1	−0.3	− 4.9	− 1.1	− 4.7	+6.3	+1.6
5	7	18	+ 5.5	−0.3	− 4.4	+ 0.8	− 8.2	+4.1	−4.1
7	9	54	+ 7.4	−0.3	− 4.7	+ 2.4	− 1.6	−0.2	−1.8
8	14	24	+ 8.5	−0.3	− 4.2	+ 4.0	+ 2.9	−2.5	+0.4
11	13	44	+ 4.2	−0.3	− 2.6	+ 1.3	+ 6.7	−5.4	+1.3
12	15	15	+ 3.6	−0.3	− 3.4	− 0.1	+ 8.3	−5.9	+2.4
13	15	28	+ 7.4	−0.3	− 4.5	+ 2.6	+ 8.6	−7.0	+1.6
16	15	49	− 2.6	−0.3	+ 1.3	− 1.6	+ 7.3	−8.0	−0.7
17	17	14	− 9.9	−0.3	+ 6.2	− 4.0	+ 9.7	−7.7	+2.0
25	8	19	+12.4	−0.3	−11.3	+ 0.8	+ 1.9	+2.7	+4.6
26	6	51	+ 5.9	−0.3	− 8.1	− 2.5	− 0.8	+3.7	+2.9
27	7	42	+ 4.9	−0.3	− 5.0	− 0.4	− 3.9	+4.9	+1.0
29	8	58	+ 3.4	−0.3	− 4.0	− 0.9	− 6.8	+7.2	+0.4
30	8	57	+ 4.9	−0.3	− 4.8	− 0.2	− 6.9	+7.3	+0.4
31	7	18	+ 2.7	−0.3	− 5.5	− 3.1	− 5.6	+6.6	+1.0
June 1	7	15	+ 4.4	−0.3	− 5.5	− 1.4	− 4.5	+4.8	+0.3
2	8	29	+ 3.8	−0.3	− 5.1	− 1.6	− 3.0	+2.9	−0.1
3	8	6	+ 3.1	−0.3	− 4.1	− 1.3	− 1.0	+1.3	+0.3

Approx. G.M.T. 1849			Longitude.				E.N.P.D.		
			B—O	Corr. to B.	H—B	H—O	B—O	H—B	H—O
d	h	m							
June 4	8	17	+ 3·7	−0·3	− 3·2	+0·2	− 0·8	−0·6	−1·4
6	10	15	+ 0·7	−0·3	− 2·9	−2·5	+ 1·0	−3·0	−2·0
7	12	59	+ 4·4	−0·3	− 3·3	+0·8	+ 4·3	−3·6	+0·7
8	11	45	+ 3·4	−0·3	− 3·9	−0·8	+ 2·9	−4·2	−1·3
9	12	19	+ 6·4	−0·3	− 4·7	+1·4	+ 6·7	−4·8	+1·9
10	13	57	+ 6·7	−0·3	− 5·7	+0·7	+ 6·3	−5·4	+0·9
11	14	21	+ 4·8	−0·3	− 6·4	−1·9	+ 8·3	−6·6	+1·7
12	14	22	+ 9·5	−0·3	− 6·9	+2·3	+ 8·2	−7·6	+0·6
13	14	13	+10·5	−0·3	− 6·6	+3·6	+13·0	−8·5	+4·5
14	14	46	+ 6·4	−0·3	− 4·9	+1·2	+11·3	−8·9	+2·4
15	14	51	+ 0·8	−0·3	− 2·1	−1·6	+ 7·0	−8·5	−1·5
16	15	52	− 1·5	−0·3	+ 1·7	−0·1	+ 8·7	−7·2	+1·5
17	15	24	+ 0·2	−0·3	+ 3·3	+3·2	+11·2	−5·8	+5·4
22	8	42	+20·3	−0·3	−19·5	+0·5	− 2·9	+2·6	−0·3
23	8	53	+15·7	−0·3	−17·9	−2·5	− 1·0	+3·8	+2·8
24	8	53	+14·4	·0·3	−13·5	+0·6	− 9·8	+4·3	−5·5
25	9	12	+ 6·4	−0·3	− 9·2	−3·1	− 5·5	+4·6	−0·9
26	9	8	+ 5·0	−0·3	− 6·4	−1·7	− 5·9	+4·4	−1·5
27	7	53	+ 5·1	−0·3	− 5·8	−1·0	− 7·2	+3·9	−3·3
28	9	16	+ 3·1	−0·3	− 6·3	−3·5	− 1·8	+3·0	+1·2
30	9	4	− 3·2	−0·3	− 6·4	−9·9	− 0·7	+0·1	−0·6
July 1	8	20	− 3·6	−0·3	− 4·7	−8·6	+ 3·1	−1·4	+1·7
2	8	51	+ 0·2	−0·3	− 2·4	−2·5	+ 4·4	−2·6	+1·8
4	10	33	+ 2·5	−0·3	− 0·2	+2·0	+ 4·8	−3·4	+1·4
5	9	51	+ 1·0	−0·3	− 0·8	−0·1	+ 1·9	−3·3	−1·4
6	10	29	+ 5·4	−0·3	− 2·8	+2·3	+ 2·8	−3·2	−0·4
7	10	50	+ 3·3	−0·3	− 4·9	−1·9	+ 2·2	−3·1	−0·9
8	10	48	+ 5·5	−0·3	− 5·9	−0·7	− 1·9	−3·4	−5·3
9	11	42	+ 4·0	−0·3	− 7·0	−3·3	+ 5·9	−3·7	+2·2
10	12	45	+11·3	−0·3	− 8·2	+2·8	+ 4·4	−4·1	+0·3
11	12	15	+13·0	−0·3	− 9·7	+3·0	+ 2·4	−4·9	−2·5
12	13	22	+13·6	−0·3	−11·2	+2·1	+ 5·6	−5·0	+0·6
13	12	53	+12·2	−0·3	−11·0	+0·9	+ 1·9	−4·4	−2·5
15	14	5	+ 3·2	−0·3	− 3·7	−0·8	+ 0·3	−1·0	−0·7
16	15	3	− 2·4	−0·3	− 0·5	−3·2	− 4·9	+1·2	−3·7
23	7	57	+14·3	−0·3	−17·3	−3·3	− 9·4	+7·2	−2·2
24	8	0	+11·3	−0·3	−12·8	−1·8	− 4·5	+5·7	+1·2
25	8	50	+ 6·8	−0·3	− 9·0	−2·5	− 2·7	+3·8	+1·1
26	8	11	+ 2·8	−0·3	− 7·2	−4·7	+ 0·7	+1·9	+2·6
27	8	34	+ 5·1	−0·3	− 6·4	−1·6	− 1·1	−0·1	−1·2
28	8	21	0·0	−0·3	− 5·7	−6·0	+ 0·1	−1·9	−1·8
29	9	9	+ 3·4	−0·3	− 4·9	−1·8	+ 4·0	−3·7	+0·3
30	7	51	+ 3·3	−0·3	− 3·6	−0·6	+ 3·8	−4·7	−0·9
31	8	10	+ 1·4	−0·3	− 1·9	−0·8	+ 4·5	−5·1	−0·6

Errors of Hansen's Tables deduced

Approx. G.M.T. 1849			Longitude.				B.N.P.D.		
			B−O	Corr. to B.	H−B	H−O	B−O	H−B	H−O
d	h	m							
Aug. 1	7	21	− 0.3	−0.3	− 0.8	−1.4	+ 6.0	−5.0	+1.0
3	10	47	+ 1.8	−0.3	− 1.2	+0.3	+ 3.9	−3.7	+0.2
4	8	51	+ 2.6	−0.3	− 2.6	−0.3	+ 1.9	−3.3	−1.4
5	9	25	+ 4.8	−0.3	− 3.6	+0.9	+ 2.4	−3.0	−0.6
6	9	35	+ 2.4	−0.3	− 4.3	−2.2	+ 3.9	−2.6	+1.3
7	16	14	+ 7.7	−0.3	− 5.6	+1.8	+ 5.0	−2.4	+2.6
8	10	49	+10.7	−0.3	− 7.1	+3.3	+ 2.4	−2.5	−0.1
9	11	9	+11.0	−0.3	− 9.9	+0.8	0.0	−2.1	−2.1
10	11	33	+16.2	−0.3	−12.3	+3.6	− 1.5	−1.5	−3.0
11	13	55	+ 9.6	−0.3	−12.6	−3.3	− 6.2	+0.1	−6.1
12	12	56	+11.5	−0.3	− 9.8	+1.4	− 6.0	+2.0	−4.0
13	14	5	+ 6.6	−0.3	− 5.6	+0.7	− 8.2	+4.2	−4.0
14	15	12	+ 3.6	−0.3	− 3.1	+0.2	−10.9	+6.7	−4.2
15	16	0	+ 4.6	−0.3	− 4.1	+0.2	−12.0	+8.8	−3.2
23	8	22	+17.3	−0.3	−11.0	+6.0	− 6.8	+3.8	−3.0
24	7	0	+ 6.6	−0.3	− 7.1	−0.8	− 3.4	+1.6	−1.8
25	9	24	+11.1	−0.3	− 3.6	+7.2	− 2.3	−1.0	−3.3
26	8	30	+ 7.6	−0.3	− 2.1	+5.2	+ 3.4	−2.4	+1.0
28	9	51	+ 0.5	−0.3	− 0.9	−0.7	+ 4.6	−4.6	0.0
31	8	51	− 0.3	−0.3	− 0.9	−1.5	+ 4.3	−4.7	−0.4
Sept. 2	11	57	+ 4.7	−0.3	− 3.5	+0.9	+ 7.3	−3.7	+3.6
4	8	48	+ 3.7	−0.3	− 4.2	−0.8	+ 0.9	−2.5	−1.6
5	9	1	+ 5.6	−0.3	− 4.4	+0.9	− 0.8	−2.0	−2.8
6	9	13	+ 3.8	−0.3	− 5.6	−2.1	+ 3.2	−1.6	+1.6
7	10	0	+ 8.6	−0.3	− 7.7	+0.6	− 0.8	−1.1	−1.9
8	11	52	+ 9.5	−0.3	− 9.8	−0.6	− 2.0	−0.2	−2.2
9	18	40	+11.8	−0.3	−10.2	+1.3	− 1.2	+1.7	+0.5
10	17	45	+ 8.5	−0.3	− 9.4	−1.2	− 4.0	+3.5	−0.5
11	16	56	+ 8.2	−0.3	− 8.0	−0.1	− 9.4	+5.7	−3.7
19	6	16	+22.8	−0.3	−22.8	−0.3	− 6.4	+7.1	+0.7
21	7	2	+12.1	−0.3	−12.9	−1.1	− 6.8	+1.7	−5.1
24	7	31	+ 1.5	−0.3	− 0.5	+0.7	+ 4.2	−2.7	+1.5
25	5	24	− 3.1	−0.3	+ 0.5	−2.9	+ 5.4	−3.5	+1.9
26	6	18	− 2.4	−0.3	+ 1.2	−1.5	+ 4.6	−4.3	+0.3
28	6	44	+ 0.7	−0.3	+ 1.5	+1.9	+ 3.0	−5.4	−2.4
30	6	30	+ 4.4	−0.3	− 1.9	+2.2	+ 2.7	−5.4	−2.7
Oct. 2	7	26	+12.1	−0.3	− 6.8	+5.0	+ 0.1	−3.7	−3.6
3	10	1	+13.6	−0.3	− 8.2	+5.1	+ 1.9	−1.9	0.0
4	13	0	+ 4.1	−0.3	− 8.5	−4.7	− 0.9	−0.8	−1.7
5	14	55	+ 2.7	−0.3	− 8.3	−5.9	+ 2.4	+0.6	+3.0
6	18	4	+ 7.7	−0.3	− 8.4	−1.0	− 1.8	+1.9	+0.1
8	11	23	+ 9.6	−0.3	− 9.8	−0.5	− 3.7	+4.5	+0.8

Approx. G.M.T. 1849			Longitude.				E.N.P.D.		
			B−O	Corr. to B.	H−B	H−O	B−O	H−B	H−O
	d	h m							
Oct. 9	12	10	+ 7·6	−0·3	− 10·6	− 3·3	− 11·7	+ 6·1	− 5·6
10	17	25	+ 12·0	−0·3	− 10·4	+ 1·3	− 9·9	+ 8·5	− 1·4
11	17	24	+ 9·5	−0·3	− 9·7	− 0·5	− 12·7	+ 10·0	− 2·7
13	17	28	+ 5·6	−0·3	− 10·7	− 5·4	− 14·5	+ 10·5	− 4·0
18	5	40	+ 24·0	−0·3	− 24·4	− 0·7	− 0·5	+ 2·0	+ 1·5
19	5	38	+ 21·8	−0·3	− 20·9	+ 0·6	− 1·9	− 0·1	− 2·0
21	5	3	+ 7·4	−0·3	− 9·4	− 2·3	+ 1·5	− 2·7	− 1·2
23	5	59	+ 3·8	−0·3	− 2·0	+ 1·5	− 2·8	− 4·3	− 7·1
24	5	7	− 0·9	−0·3	− 0·9	− 2·1	+ 6·5	− 5·2	+ 1·3
25	10	32	+ 1·1	−0·3	− 0·3	+ 0·5	+ 6·7	− 6·3	+ 0·4
26	4	42	+ 1·9	−0·3	− 0·2	+ 1·4	+ 4·9	− 6·9	− 2·0
27	4	58	+ 2·2	−0·3	− 0·7	+ 1·2	+ 5·5	− 7·5	− 2·0
28	5	49	+ 4·3	−0·3	− 2·1	+ 1·9	+ 4·1	− 7·8	− 3·7
29	5	53	+ 4·7	−0·3	− 4·4	0·0	+ 6·6	− 6·9	− 0·3
30	5	45	+ 13·8	−0·3	− 7·2	+ 6·3	+ 0·1	− 5·5	− 5·4
31	6	49	+ 13·4	−0·3	− 10·0	+ 3·1	− 0·4	− 3·5	− 3·9
Nov. 1	6	45	+ 10·2	−0·3	− 11·3	− 1·4	− 1·7	− 1·4	− 3·1
2	7	30	+ 11·2	−0·3	− 10·9	0·0	− 5·8	+ 0·9	− 4·9
4	10	32	+ 11·0	−0·3	− 8·5	+ 2·2	− 12·7	+ 5·5	− 7·2
5	10	13	+ 8·9	−0·3	− 8·4	+ 0·2	− 13·3	+ 7·8	− 5·5
6	11	24	+ 7·2	−0·3	− 9·6	− 2·7	− 13·5	+ 10·0	− 3·5
12	18	38	+ 11·5	−0·3	− 11·9	− 0·7	− 14·2	+ 7·1	− 7·1
17	4	48	+ 21·3	−0·3	− 20·6	+ 0·4	− 0·1	− 1·8	− 1·9
21	8	4	+ 6·2	−0·3	− 5·8	+ 0·1	+ 6·4	− 4·1	+ 2·3
22	5	42	+ 4·0	−0·3	− 5·6	− 1·9	+ 5·4	− 4·9	+ 0·5
24	4	44	+ 2·8	−0·3	− 8·1	− 5·6	+ 7·8	− 6·6	+ 1·2
25	5	36	+ 13·0	−0·3	− 10·4	+ 2·3	+ 10·2	− 6·9	+ 3·3
26	4	35	+ 15·9	−0·3	− 11·7	+ 3·9	+ 6·4	− 6·4	0·0
27	5	27	+ 14·3	−0·3	− 12·4	+ 1·6	+ 1·2	− 5·1	− 3·9
28	6	33	+ 8·8	−0·3	− 12·7	− 4·2	+ 1·4	− 3·2	− 1·8
29	5	15	+ 12·5	−0·3	− 12·7	− 0·5	− 2·7	− 1·2	− 3·9
30	8	43	+ 9·3	−0·3	− 12·2	− 3·2	− 6·6	+ 1·3	− 5·3
Dec. 1	7	21	+ 11·6	−0·3	− 10·5	+ 0·8	− 3·0	+ 3·3	+ 0·3
3	21	16	+ 7·5	−0·3	− 5·0	+ 2·2	− 9·9	+ 8·6	− 1·3
4	10	18	+ 1·9	−0·3	− 4·7	− 3·1	− 10·7	+ 9·8	− 0·9
5	13	52	+ 5·0	−0·3	− 6·0	− 1·3	− 17·4	+ 11·6	− 5·8
6	16	16	+ 10·3	−0·3	− 8·6	+ 1·4	− 13·0	+ 12·2	− 0·8
8	15	44	+ 7·3	−0·3	− 8·7	− 1·7	− 12·4	+ 10·2	− 2·2
17	4	47	+ 17·8	−0·3	− 15·2	+ 2·3	+ 2·0	− 1·2	+ 0·8
18	5	6	+ 10·3	−0·3	− 12·6	− 2·6	+ 1·1	− 0·9	+ 0·2
19	6	14	+ 8·3	−0·3	− 9·3	− 1·3	+ 2·8	− 0·6	+ 2·2
20	5	5	+ 2·9	−0·3	− 7·0	− 4·4	+ 2·7	− 0·7	+ 2·0

Approx. G.M.T. 1849.			B−O	Longitude. Corr. to B.	H−B	H−O	R.N.P.D. B−O	H−B	H−O
	d	h m							
Dec. 21		5 59	+ 6˙0	−0˙3	− 6˙6	−0˙9	+1˙9	−0˙9	+1˙0
23		4 1	+ 7˙8	−0˙3	−11˙4	−3˙9	+2˙9	−2˙0	+0˙9
25		6 22	+11˙8	−0˙3	−17˙7	−6˙2	+3˙5	−1˙2	+2˙3
26	11	11	+13˙3	−0˙3	−18˙1	−5˙1	+2˙1	+0˙4	+2˙5
27		6 23	+ 7˙9	−0˙3	−17˙4	−9˙8	−1˙3	+1˙6	+0˙3
28		7 9	+13˙6	−0˙3	−16˙5	−3˙2	−1˙9	+3˙2	+1˙3
29		5 46	+ 9˙6	−0˙3	−15˙7	−6˙4	−8˙9	+4˙4	−4˙5
30		7 5	+ 6˙5	−0˙3	−13˙8	−7˙6	−8˙0	+5˙7	−2˙3
31	11	29	+ 7˙5	−0˙3	−10˙4	−3˙2	−5˙2	+6˙7	+1˙5

Approx. G.M.T. 1850.		B−0	Longitude. Corr. to B.	H−B	H−0	E.N.P.D. B−0	H−B	H−0
	d h m	"	"	"	"	"	"	"
Jan.	1 10 44	+ 4·1	−0·3	− 7·0	− 3·2	− 6·8	+7·3	+0·5
	4 13 29	+ 5·8	−0·3	− 7·6	− 2·1	− 7·2	+6·3	−0·9
	5 19 16	+10·0	−0·3	− 7·8	+ 1·9	− 3·0	+4·3	+1·3
	6 15 29	+ 2·0	−0·3	− 6·9	− 5·2	− 1·9	+2·4	+0·5
	7 16 58	− 2·8	−0·3	− 4·0	− 7·1	+ 0·8	+0·4	+1·2
	23 8 32	+ 5·3	−0·3	−14·0	− 9·0	− 1·7	+2·5	+0·8
	25 5 48	+ 9·1	−0·3	−17·3	− 8·5	− 4·5	+5·0	+0·5
	26 7 9	+15·9	−0·3	−18·3	− 2·7	− 6·1	+6·5	+0·4
	27 6 54	+14·4	−0·3	−19·1	− 5·0	− 4·5	+7·5	+3·0
	28 19 38	+19·5	−0·3	−17·6	+ 1·6	− 3·0	+8·0	+5·0
	30 8 59	+ 7·6	−0·3	−13·7	− 6·4	− 6·8	+7·0	+0·2
Feb.	1 13 31	+ 9·1	−0·3	− 8·8	0·0	− 4·9	+3·2	−1·7
	2 16 1	+ 9·3	−0·3	− 8·0	+ 1·0	− 0·2	+1·0	+0·8
	3 15 25	+ 9·1	−0·3	− 7·6	+ 1·2	+ 1·6	−1·2	+0·4
	4 18 16	+ 5·3	−0·3	− 5·6	− 0·6	− 0·1	−3·3	−3·4
	5 17 51	+ 6·2	−0·3	− 3·0	+ 2·9	+ 4·3	−4·7	−0·4
	6 17 5	− 5·7	−0·3	+ 0·4	− 5·6	+ 3·7	−5·5	−1·8
	16 5 18	− 1·3	−0·3	− 2·0	− 3·6	+ 3·1	−0·9	+2·2
	18 5 31	− 2·8	−0·3	− 1·1	− 4·2	+ 1·1	−0·4	+0·7
	19 8 19	− 8·1	−0·3	− 3·9	−12·3	+ 1·2	+0·1	+1·3
	20 6 17	− 0·2	−0·3	− 7·6	− 8·1	− 0·7	+1·1	+0·4
	21 7 7	+ 2·7	−0·3	−11·7	− 9·3	− 2·4	+2·9	+0·5
	22 5 23	+10·9	−0·3	−14·5	− 3·9	− 6·6	+4·7	−1·9
	23 6 29	+ 8·5	−0·3	−16·1	− 7·9	− 5·3	+6·9	+1·6
	24 13 20	+20·1	−0·3	−16·1	+ 3·7	−12·2	+9·1	−3·1
	26 9 19	+10·8	−0·3	−15·0	− 4·5	−10·7	+9·7	−1·0
	27 9 16	+13·6	−0·3	−13·8	− 0·5	−11·9	+8·7	−3·2
Mar.	2 17 38	+14·5	−0·3	− 9·0	+ 5·2	− 2·2	+2·0	−0·2
	3 15 49	+10·1	−0·3	− 8·1	+ 1·7	− 1·6	−0·1	−1·7
	4 14 52	+ 4·9	−0·3	− 7·2	− 2·6	+ 2·6	−1·9	+0·7
	5 15 54	+ 6·3	−0·3	− 6·3	− 0·3	− 2·1	−3·6	−5·7
	6 16 5	+ 6·4	−0·3	− 4·7	+ 1·4	+ 2·0	−4·5	−2·5
	15 6 28	− 5·3	−0·3	+ 1·9	− 3·7	+ 1·1	−0·7	+0·4
	16 6 25	− 5·7	−0·3	− 0·5	− 6·5	+ 0·3	−0·5	−0·2
	17 6 13	− 0·7	−0·3	− 1·8	− 2·8	+ 3·8	−0·5	+3·3
	18 6 7	− 0·9	−0·3	− 3·1	− 4·3	+ 2·7	−0·3	+2·4
	21 7 57	+ 6·4	−0·3	−13·0	− 6·9	− 2·0	+2·7	+0·7
	22 10 41	+11·4	−0·3	−16·7	− 5·6	− 3·5	+5·2	+1·7

i

Errors of Hansen's Tables deduced

Approx. G.M.T. 1850.			Longitude.			E.N.P.D.		
		B–O	Corr. to B.	H–B	H–O	B–O	H–B	H–O
	d h m							
Mar. 23	6 28	+13ˮ8	−0ˮ3	−17ˮ6	−4ˮ1	− 5ˮ5	+ 7ˮ2	+1ˮ7
24	10 28	+12·0	−0·3	−15·9	−4·2	−10·8	+ 9·6	−1·2
25	6 35	+ 6·2	−0·3	−13·5	−7·6	− 8·7	+10·5	+1·8
26	9 6	+ 6·1	−0·3	− 9·8	−4·0	− 9·7	+10·5	+0·8
27	9 10	+ 4·7	−0·3	− 6·9	−2·5	−10·8	+ 9·5	−1·3
28	8 21	+·5·0	−0·3	− 5·5	−0·8	−10·3	+ 7·9	··2·4
29	9 28	+ 4·6	−0·3	− 4·9	−0·6	−10·2	+ 5·8	−4·4
30	15 43	+ 0·7	−0·3	− 5·2	−4·8	− 3·7	+ 3·4	−0·3
31	11 38	+ 5·8	−0·3	− 5·2	+0·3	− 5·0	+ 1·5	−3·5
Apr. 2	17 34	+ 8·6	−0·3	− 5·6	+2·7	+ 3·0	− 2 5	+0·5
4	16 19	+ 7·2	−0·3	− 4·5	+2·4	+ 5·8	− 4·8	+1·0
15	7 1	+ 6·6	−0·3	− 5·4	+0·9	+ 5·1 ⌒+ 1·8		+6·9
17	9 54	+11·1	−0·3	−10·8	0·0	+ 2·8	+ 3·8	+6·6
18	7 4	+ 5·8	−0·3	−12·5	−7·0	− 4·7	+ 5·1	+0·4
20	7 54	+18·0	−0·3	−15·8	+1·9	− 9·4	+ 8·8	−0·6
21	6 47	+14·0	−0·3	−16·2	−2·5	−10·0	+10·2	+0·2
22	8 41	+11·9	−0·3	−14·6	−3·0	−12·3	+11·3	−1·0
23	11 9	+ 8·0	−0·3	−11·2	−3·5	− 9·2	+10·2	+1·0
24	7 58	+ 6·7	−0·3	− 7·9	−1·5	− 8·4	+ 8·9	+0·5
25	7 17	+ 5·1	−0·3	− 4·6	+0·2	− 8·9	+ 7·1	−1·8
26	8 36	+ 1·3	−0·3	− 2·8	−1·8	− 7·7	+ 5·1	−2·6
27	9 17	+ 1·5	−0·3	− 2·3	−1·1	− 6·1	+ 3·2	−2·9
28	11 23	+ 4·6	−0·3	− 2·6	+1·7	− 2·1	+ 0·8	−1·3
29	11 50	+ 0·5	−0·3	− 2·8	−2·6	+ 2·4	− 0·9	+1·5
May 1	15 36	+ 1·3	−0·3	− 3·0	−2·0	+ 4·2	− 4·1	+0·1
2	13 51	+ 3·1	−0·3	− 3·1	−0·3	+ 2·7	− 5·2	−2·5
3	14 58	+ 5·2	−0·3	− 1·8	+3·1	+ 9·2	− 6·5	+2·7
4	16 22	− 2·8	−0·3	+ 1·1	−2·0	+ 9·5	− 7·4	+2·1
13	8 7	+ 8·9	−0·3	−13·3	−4·7	+ 1·5	+ 0·4	+1·9
15	7 6	+11·9	−0·3	−17·1	−5·5	− 2·8	+ 4·3	+1·5
18	7 11	+ 5·2	−0·3	− 9·6	−4·7	−11·2	+ 8·9	−2·3
19	7 13	+ 2·1	−0·3	− 9·7	−7·9	−10·7	+ 9·4	−1·3
20	6 15	+12·0	−0·3	−10·4	+1·3	−13·7	+ 9·4	−4·3
21	7 28	+ 6·1	−0·3	−10·2	−4·4	− 9·4	+ 8·4	−1 0
22	7 0	+ 7·2	−0·3	− 9·2	−2·3	− 9·1	+ 6·6	−2·5
23	6 38	+ 4·9	−0·3	− 7·3	−2·7	− 6·9	+ 4·9	−2·0
24	8 21	+ 5·9	−0·3	− 5·5	+0·1	− 5·2	+ 2·9	−2·3
25	14 30	+ 9·9	−0·3	− 5·1	+4·5	− 0·4	+ 0·9	+0·5
26	9 53	+ 9·5	−0·3	− 5·4	+3·8	− 2·9	− 0·3	−3·2
27	12 23	+ 6·7	−0·3	− 4·7	+1·7	+ 1·9	− 1·3	+0·6
28	11 23	+ 8·1	−0·3	− 3·6	+4·2	− 2·3	− 2·4	−4·7
30	13 12	+ 3·1	−0·3	− 0·8	+2·0	+ 5·8	− 4·5	+1·3
31	13 13	+ 1·5	−0·3	+ 0·1	+1·3	+ 2·5	− 5·5	−3·0

Approx. G.M.T. 1850.			B–O	Longitude. Corr. to B.	H–B	H–O	R.N.P.D. B–O	H–B	H–O
d	h	m							
June 1	15	38	− 2ʺ·8	−0ʺ·3	+ 0ʺ·6	− 2ʺ·5	+ 8ʺ·3	− 6ʺ·9	+ 1ʺ·4
2	14	14	− 2·7	−0·3	+ 0·9	− 2·1	+ 3·9	− 7·9	− 4·0
3	15	13	− 4·9	−0·3	+ 1·6	− 3·6	+ 6·1	− 8·7	− 2·6
5	16	26	− 3·2	−0·3	+ 3·9	+ 0·4	+ 10·8	− 8·8	+ 2·0
6	15	40	− 6·8	−0·3	+ 3·8	− 3·3	+ 4·3	− 8·3	− 4·0
13	7	58	+25·5	−0·3	− 26·0	− 0·8	+ 3·5	+ 5·1	+ 8·6
14	9	47	+24·0	−0·3	− 19·0	+ 4·7	− 4·5	+ 6·5	+ 2·0
15	8	14	+ 10·4	−0·3	− 13·4	− 3·3	− 3·6	+ 6·9	+ 3·3
16	8	0	+11·3	−0·3	− 9·8	+ 1·2	− 3·6	+ 7·0	+ 3·4
17	8	31	+ 8·3	−0·3	− 7·8	+ 0·2	− 1·7	+ 6·1	+ 4·4
18	8	32	+ 9·9	−0·3	− 7·0	+ 2·6	− 2·7	+ 4·5	+ 1·8
19	9	18	+ 6·1	−0·3	− 6·1	− 0·3	+ 0·2	+ 3·0	+ 3·2
20	7	12	+ 3·6	−0·3	− 5·0	− 1·7	− 4·9	+ 1·4	− 3·5
21	7	48	+ 4·1	−0·3	− 4·2	− 0·4	− 3·7	− 0·1	− 3·8
22	7	46	+ 3·5	−0·3	− 4·3	− 1·1	− 4·2	− 1·1	− 5·3
23	9	19	+ 4·6	−0·3	− 4·5	− 0·2	− 1·0	− 2·3	− 3·3
24	9	14	+ 9·9	−0·3	− 5·1	+ 4·5	− 2·5	− 2·7	− 5·2
25	9	55	+ 5·6	−0·3	− 5·0	+ 0·3	− 4·7	− 2·6	− 7·3
27	11	41	+ 3·0	−0·3	− 1·8	+ 0·9	− 0·2	− 2·6	− 2·8
29	12	.27	+ 0·2	−0·3	+ 0·3	+ 0·2	− 1·0	− 3·1	− 4·1
30	13	43	+ 5·7	−0·3	− 1·2	+ 4·2	+ 3·0	− 4·3	− 1·3
July 1	12	53	+ 8·2	−0·3	− 3·6	+ 4·3	− 0·7	− 4·3	− 5·0
2	13	32	+11·4	−0·3	− 5·5	+ 5·6	+ 3·2	− 4·9	− 1·7
4	13	52	+ 5·3	−0·3	− 5·4	− 0·4	− 1·9	− 4·9	− 6·8
5	14	27	+ 2·9	−0·3	− 4·7	− 2·1	− 0·9	− 4·2	− 5·1
13	8	3	+19·7	−0·3	− 23·6	− 4·2	+ 1·2	+ 7·2	+ 8·4
14	8	14	+16·1	−0·3	− 17·6	− 1·8	− 0·3	+ 6·2	+ 5·9
15	7	1	+13·0	−0·3	− 13·0	− 0·3	− 3·1	+ 4·7	+ 1·6
16	8	21	+12·0	−0·3	− 9·2	+ 2·5	+ 2·2	+ 2·4	+ 4·6
18	11	33	+ 6·0	−0·3	− 4·0	+ 1·7	+ 8·0	− 1·5	+ 6·5
21.	8	36	+ 3·2	−0·3	− 0·8	+ 2·1	+ 1·6	− 4·0	− 2·4
22	8	38	+ 4·5	−0·3	− 0·6	+ 3·6	− 0·9	− 3·9	− 4·8
24	9	33	+ 3·8	−0·3	− 1·2	+ 2·3	+ 1·1	− 3·2	− 2·1
25	10	5	+ 5·0	−0·3	− 1·6	+ 3·1	− 1·6	− 2·5	− 4·1
26	12	45	+ 6·4	−0·3	− 1·8	+ 4·3	− 2·1	− 1·8	− 3·9
27	11	34	+ 6·2	−0·3	− 2·3	+ 3·6	− 0·8	− 1·4	− 2·2
29	11	17	+10·1	−0·3	− 6·0	+ 3·8	− 2·7	− 1·0	− 3·7
30	11	47	+11·0	−0·3	− 8·2	+ 2·5	− 4·6	− 1·0	− 5·6
Aug. 3	16	25	+ 7·3	−0·3	− 6·0	+ 1·0	− 7·0	+ 1·6	− 5·4
4	14	42	+ 0·1	−0·3	− 4·8	− 5·0	− 10·3	+ 2·9	− 7·4
11	8	11	+28·7	−0·3	− 26·1	+ 2·3	− 5·5	+ 9·0	+ 3·5
12	7	14	+17·9	−0·3	− 20·7	− 3·1	+ 1·9	+ 6·9	+ 8·8
13	7	12	+16·4	−0·3	− 14·9	+ 1·2	+ 0·5	+ 4·7	+ 5·2

i 2

Approx. G.M.T. 1850			Longitude.				E.N.P.D.		
			B–0	Corr. to B.	H–B	H–0	B–0	H–B	H–0
d	h	m	"	"	"	"	"	"	"
Aug. 14	7	5	+ 14·3	– 0·3	– 10·1	+ 3·9	– 3·1	+ 2·7	– 0·4
15	9	14	+ 7·6	– 0·3	– 6·5	+ 0·8	+ 3·5	+ 0·4	+ 3·9
16	6	53	+ 8·5	– 0·3	– 4·4	+ 3·8	+ 1·5	– 1·1	+ 0·4
17	10	47	+ 3·6	– 0·3	– 2·4	+ 0·9	+ 8·6	– 2·8	+ 5·8
19	7	34	+ 8·3	– 0·3	+ 0·6	+ 8·6	+ 1·8	– 3·7	– 1·9
20	9	35	+ 2·3	– 0·3	+ 1·9	+ 3·9	+ 2·6	– 3·8	– 1·2
21	10	3	+ 1·3	– 0·3	+ 1·6	+ 2·6	+ 1·7	– 3·4	– 1·7
22	8	34	+ 3·6	– 0·3	+ 0·6	+ 3·9	– 2·2	– 2·9	– 5·1
23	9	0	+ 3·8	– 0·3	– 1·5	+ 2·0	– 3·0	– 2·1	– 5·1
24	9	6	+ 7·2	– 0·3	– 3·6	+ 3·3	– 2·3	– 1·5	– 3·8
26	9	56	+ 12·3	– 0·3	– 7·0	+ 5·0	– 8·6	– 0·3	– 8·9
27	19	5	+ 7·0	– 0·3	– 8·5	– 1·8	+ 6·7	– 0·1	+ 6·6
28	16	11	+ 8·6	– 0·3	– 9·6	– 1·3	+ 2·0	+ 0·1	+ 2·1
29	11	43	+ 9·7	– 0·3	– 10·9	– 1·5	– 10·4	+ 0·3	– 10·1
30	12	5	+ 14·5	– 0·3	– 11·4	+ 2·8	– 8·2	+ 1·0	– 7·2
31	15	44	+ 6·1	– 0·3	– 9·8	– 4·0	– 9·5	+ 2·6	– 6·9
Sept. 2	14	41	+ 4·0	– 0·3	– 3·9	– 0·2	– 16·7	+ 6·0	– 10·7
4	16	39	+ 6·4	– 0·3	– 9·1	– 3·0	– 19·8	+ 10·4	– 9·4
8	6	57	+ 29·1	– 0·3	– 31·9	– 3·1	– 9·8	+ 10·8	+ 1·0
10	6	24	+ 24·4	– 0·3	– 23·5	+ 0·6	– 3·0	+ 6·9	+ 3·9
11	6	28	+ 18·3	– 0·3	– 16·8	+ 1·2	– 2·5	+ 4·8	+ 2·3
12	7	10	+ 11·6	– 0·3	– 10·6	+ 0·7	– 3·5	+ 2·8	– 0·7
13	7	4	+ 6·9	– 0·3	– 6·7	– 0·1	– 0·4	+ 1·1	+ 0·7
14	6	12	+ 5·4	– 0·3	– 4·6	+ 0·5	– 1·2	– 0·5	– 1·7
17	12	11	+ 2·3	– 0·3	– 0·8	+ 1·2	+ 3·4	– 3·7	– 0·3
18	6	29	+ 8·1	– 0·3	– 0·3	+ 7·5	+ 5·5	– 3·7	+ 1·8
20	13	18	+ 6·6	– 0·3	– 4·3	+ 2·0	+ 4·8	– 3·2	+ 1·6
21	7	46	+ 7·3	– 0·3	– 6·7	+ 0·3	– 0·6	– 2·5	– 3·1
22	8	22	+ 10·4	– 0·3	– 8·8	+ 1·3	+ 0·7	– 1·8	– 1·1
23	10	55	+ 7·8	– 0·3	– 9·2	– 1·7	+ 0·8	– 0·8	0·0
24	10	26	+ 8·7	– 0·3	– 8·0	+ 0·4	– 0·5	– 0·1	– 0·6
25	9	43	+ 5·4	– 0·3	– 6·9	– 1·8	– 1·7	– 0·1	– 1·8
26	15	12	+ 5·0	– 0·3	– 7·6	– 2·9	– 0·5	+ 0·3	– 0·2
27	17	58	+ 8·5	– 0·3	– 9·9	– 1·7	– 0·9	+ 1·4	+ 0·5
28	11	26	+ 6·5	– 0·3	– 11·3	– 5·1	– 3·9	+ 2·6	– 1·3
29	13	3	+ 7·6	– 0·3	– 11·1	– 3·8	– 6·2	+ 4·2	– 2·0
30	14	51	+ 8·5	– 0·3	– 9·0	– 0·8	– 7·6	+ 5·9	– 1·7
Oct. 1	14	48	+ 2·6	– 0·3	– 6·8	– 4·5	– 5·3	+ 7·3	+ 2·0
8	6	28	+ 36·9	– 0·3	– 29·6	+ 7·0	– 0·7	+ 3·8	+ 3·1
11	6	39	+ 20·1	– 0·3	– 11·7	+ 8·1	– 7·8	– 0·4	– 8·2
12	6	34	+ 9·0	– 0·3	– 6·6	+ 2·1	+ 0·3	– 1·6	– 1·3

Approx. G.M.T. 1850			Longitude				E.N.P.D.		
			B−O	Corr. to B.	H−B	H−O	B−O	H−B	H−O
d	h	m	"	"	"	"	"	"	"
Oct. 14	7	51	+ 5·9	−0·3	− 2·0	+3·6	+ 9·4	− 4·0	+5·4
15	5	47	+ 1·2	−0·3	− 1·7	−0·8	+ 4·2	− 4·7	−0·5
16	6	33	+ 4·4	−0·3	− 2·2	+1·9	+ 7·2	− 5·3	+1·9
17	6	25	+ 0·4	−0·3	− 3·7	−3·6	+ 5·2	− 5·5	−0·3
18	7	42	+ 4·5	−0·3	− 6·5	−2·3	+ 6·5	− 5·0	+1·5
19	8	31	+ 9·6	−0·3	−10·0	−0·7	+ 5·9	− 4·5	+1·4
20	8	56	+13·2	−0·3	−12·9	0·0	+ 4·4	− 3·4	+1·0
21	7	8	+11·0	−0·3	−13·9	−3·2	+ 0·2	− 2·4	−2·2
22	12	55	+13·9	−0·3	−12·6	+1·0	+ 0·6	− 0·6	0·0
25	11	42	+ 8·8	−0·3	− 8·5	0·0	− 4·7	+ 3·2	−1·5
26	10	7	+10·3	−0·3	− 9·9	+0·1	− 7·4	+ 5·1	−2·3
28	12	36	+ 7·4	−0·3	−13·3	−6·2	− 8·7	+ 8·7	0·0
29	15	28	+10·0	−0·3	−13·1	−3·4	− 9·8	+ 9·5	−0·3
30	16	9	+ 9·7	−0·3	−13·1	−3·7	− 8·7	+ 9·1	+0·4
Nov. 6	5	15	+31·1	−0·3	−24·7	+6·1	+ 1·7	− 1·1	+0·6
7	5	4	+27·1	−0·3	−21·2	+5·6	+ 0·4	− 2·2	−1·8
8	4	56	+16·9	−0·3	−15·6	+1·0	+ 3·4	− 3·1	+0·3
11	6	35	+ 2·2	−0·3	− 1·7	+0·2	+ 5·9	− 4·8	+1·1
12	5	22	+ 0·5	−0·3	− 0·9	−0·7	+ 6·9	− 5·3	+1·6
13	8	33	+ 1·6	−0·3	− 1·8	−0·5	+ 8·9	− 5·8	+3·1
14	5	19	+ 6·0	−0·3	− 3·4	+2·3	+ 7·6	− 5·9	+1·7
15	6	13	+ 2·1	−0·3	− 6·0	−4·2	+ 5·4	− 5·9	−0·5
16	11	24	+10·5	−0·3	− 9·7	+0·5	+ 9·0	− 5·1	+3·9
17	5	53	+15·0	−0·3	−12·1	+2·6	+ 3·4	− 4·4	−1·0
19	6	4	+19·3	−0·3	−15·6	+3·4	− 4·2	− 1·6	−5·8
21	11	54	+11·1	−0·3	−14·0	−3·2	− 4·2	+ 2·5	−1·7
22	15	57	+13·0	−0·3	−12·4	+0·3	− 5·8	+ 5·4	−0·4
23	10	22	+10·0	−0·3	−11·8	−2·1	−10·2	+ 7·1	−3·1
24	11	0	+ 9·6	−0·3	−12·2	−2·9	−13·2	+ 9·7	−3·5
25	13	7	+ 8·1	−0·3	−14·1	−6·3	−12·5	+11·3	−1·2
27	15	16	+18·6	−0·3	−18·2	+0·1	−11·4	+11·0	−0·4
28	17	17	+19·3	−0·3	−17·9	+1·1	−11·1	+ 8·9	+2·2
29	19	23	+16·4	−0·3	−15·4	+0·7	− 3·8	+ 6·1	+2·3
Dec. 7	4	35	+13·4	−0·3	−10·7	+2·4	+ 3·0	− 3·2	−0·2
12	5	18	+ 2·5	−0·3	− 3·8	−1·6	+ 3·7	− 2·8	+0·9
13	6	30	+ 1·8	−0·3	− 6·7	−5·2	+ 1·4	− 2·7	−1·3
14	9	31	+10·1	−0·3	− 9·7	+0·1	+ 3·8	− 2·3	+1·5
15	15	25	+16·9	−0·3	−12·3	+4·3	+ 0·9	− 1·6	−0·7
16	6	52	+14·2	−0·3	−13·4	+0·5	+ 4·0	− 0·9	+3·1
17	5	3	+12·6	−0·3	−14·9	−2·6	+ 1·4	+ 0·1	+1·5
18	13	51	+15·4	−0·3	−17·0	−1·9	− 2·9	+ 2·0	−0·9
19	6	13	+12·2	−0·3	−17·7	−5·8	− 3·6	+ 3·0	−0·6

Approx. G.M.T. 1850.			Longitude.				E.N.P.D.		
			B−O	Corr. to B.	H−B	H−O	B−O	H−B	H−O
d	h	m							
Dec. 20	8	6	+19ʺ4	−0ʺ3	−17ʺ5	+1ʺ6	− 3ʺ5	+ 4ʺ8	+1ʺ3
21	16	36	+11·0	−0·3	−15·3	−4·6	− 5·7	+ 7·5	+1·8
22	11	13	+12·2	−0·3	−14·1	−2·2	−10·9	+ 8·7	−2·2
23	11	49	+15·4	−0·3	−14·5	+0·6	− 7·7	+ 9·6	+1·9
24	19	40	+15·9	−0·3	−17·2	−1·6 ·	−11·9	+ 9·2	−2·7
25	15	36	+19·9	−0·3	−19·1	+0·5	− 6·8	+ 8·3	+1·5
27	16	52	+19·6	−0·3	−16·1	+3·2	− 5·0	+ 3·2	−1·8
29	17	59	+ 3·2	−0·3.	− 5·4	−2·5	+ 0·3	− 1·3	−1·0

Approx. G.M.T. 1851.			Longitude.				E.N.P.D.		
			B−O	Corr. to B.	H−B	H−O	B−O	H−B	H−O
	d	h m	″	″	″	″	″	″	″
Jan. 5	5	11	+10·7	−0·3	− 6·2	+4·2	+ 3·9	−1·9	+2·0
6	6	14	+ 3·6	−0·3	− 3·4	−0·1	+ 2·6	−0·8	+1·8
8	6	3	+ 2·0	−0·3	− 1·6	+0·1	+ 2·8	+0·6	+3·4
9	6	43	− 0·7	−0·3	− 2·4	−3·4	+ 0·8	+1·0	+1·8
12	5	37	+15·0	−0·3	−11·0	+3·7	− 5·4	+1·7	−3·7
15	5	9	+19·9	−0·3	−18·5	+1·1	− 6·8	+3·9	−2·9
16	14	41	+20·7	−0·3	−20·6	−0·2	− 0·2	+5·4	+5·2
17	15	53	+28·7	−0·3	−21·0	+7·4	− 4·4	+6·6	+2·2
18	7	21	+18·4	−0·3	−20·7	−2·6	− 8·2	+7·1	−1·1
19	16	12	+17·8	−0·3	−18·3	−0·8	− 7·6	+7·3	−0·3
21	17	57	+14·7	−0·3	−14·4	0·0	− 1·1	+5·0	+3·9
22	13	10	+14·2	−0·3	−14·0	−0·1	− 5·3	+3·8	−1·5
23	14	4	+ 8·3	−0·3	−13·8	−5·8	− 2·7	+1·3	−1·4
24	16	27	+16·7	−0·3	−11·9	+4·5	+ 2·0	−1·3	+0·7
25	16	46	+11·4	−0·3	− 8·4	+2·7	+ 0·9	−3·3	−2·4
26	17	53	+ 3·0	−0·3	− 3·4	−0·7	+ 2·5	−5·2	−2·7
27	20	3	− 3·2	−0·3	+ 3·1	−0·4	+ 9·6	−6·1	+3·5
Feb. 4	5	22	+ 2·5	−0·3	− 1·8	+0·4	+ 3·2	−1·1	+2·1
6	6	15	+ 1·7	−0·3	− 1·2	+0·2	+ 2·3	+0·5	+2·8
8	6	43	+ 4·3	−0·3	− 2·7	+1·3	+ 0·3	+1·0	+1·3
9	7	52	+ 9·2	−0·3	− 6·0	+2·9	− 1·3	+1·3	0·0
10	7	59	+ 8·9	−0·3	−10·3	−1·7	− 1·5	+2·1	+0·6
11	5	0	+14·1	−0·3	−14·2	−0·4	− 5·0	+2·9	−2·1
12	5	13	+16·4	−0·3	−17·7	−1·6	−10·0	+4·3	−5·7
13	6	36	+15·3	−0·3	−19·8	−4·8	− 6·1	+5·8	−0·3
14	8	52	+21·0	−0·3	−20·4	+0·3	− 4·2	+7·0	+2·8
15	7	45	+18·4	−0·3	−20·5	−2·4	− 6·5	+7·8	+1·3
16	7	51	+13·0	−0·3	−20·1	−7·4	− 9·5	+7·6	−1·9
17	9	31	+18·7	−0·3	−18·3	+0·1	− 9·4	+6·7	−2·7
21	13	50	+ 4·8	−0·3	− 5·6	−1·1	+ 1·6	−1·3	+0·3
22	15	30	+ 2·0	−0·3	− 4·2	−2·5	+ 2·6	−3·4	−0·8
24	17	20	− 6·1	−0·3	+ 1·4	−5·0	+ 1·9	−6·2	−4·3
Mar. 8	9	25	+ 1·0	−0·3	− 3·0	−2·3	+ 2·8	−0·5	+2·3
9	6	56	+ 1·9	−0·3	− 4·9	−3·3	+ 2·6	−0·6	+2·0
10	8	53	+ 4·8	−0·3	− 8·7	−4·2	+ 2·2	+0·1	+2·3
11	8	17	+13·7	−0·3	−13·3	+0·1	− 3·4	+1·7	−1·7
13	5	32	+12·2	−0·3	−18·0	−6·1	− 6·5	+5·7	−0·8
14	6	58	+13·2	−0·3	−17·2	−4·3	− 6·4	+7·8	+1·4

Errors of Hansen's Tables deduced

Approx. G.M.T. 1851			Longitude.				E.N.P.D.		
d	h	m	B−O	Corr. to B.	H−B	H−O	B−O	H−B	H−O
Mar. 15	7	13	+ 12·4	−0·3	− 16·2	− 4·1	− 10·6	+ 8·8	− 1·8
16	8	6	+ 11·0	−0·3	− 15·2	− 4·5	− 9·8	+ 9·0	− 0·8
16	8	52	+ 12·8	−0·3	− 13·1	− 0·6	− 10·6	+ 7·3	− 3·3
19	10	59	+ 7·3	−0·3	− 10·3	− 3·3	− 10·6	+ 5·6	− 5·0
20	12	34	+ 9·9	−0·3	− 6·7	+ 2·9	− 5·4	+ 3·6	− 1·8
21	13	22	+ 6·7	−0·3	− 4·1	+ 2·3	− 2·1	+ 1·7	− 0·4
23	17	9	+ 4·7	−0·3	− 2·6	+ 1·8	+ 4·5	− 2·5	+ 2·0
24	16	51	+ 6·7	−0·3	− 1·7	+ 4·7	+ 4·1	− 3·7	+ 0·4
26	18	18	(+ 1·5)	−0·3	+ 5·2	(+6·4)	(+15·6)	− 5·3	(+10·3)
Apr. 5	7	28	+ 0·4	−0·3	− 4·8	−4·7	+ 5·3	+0·4	+ 5·7
6	8	31	+ 1·6	−0·3	− 7·8	−6·5	+ 1·5	+0·9	+ 2·4
8	8	21	+ 10·5	−0·3	− 15·0	−4·8	− 3·9	+3·1	− 0·8
9	6	21	+ 14·4	−0·3	− 17·7	−3·6	− 5·1	+ 5·2	+ 0·1
10	7	48	+ 11·8	−0·3	− 19·3	−7·8	− 7·6	+7·4	− 0·2
11	12	12	+ 13·1	−0·3	− 18·6	−5·8	− 8·2	+9·4	+ 1·2
12	6	21	+ 11·7	−0·3	− 16·8	−5·4	− 7·6	+9·9	+ 2·3
13	6	27	+ 9·7	−0·3	− 14·1	−4·7	− 10·2	+9·8	− 0·4
17	12	43	+ 5·8	−0·3	− 7·8	−2·3	− 7·1	+5·1	− 2·0
18	13	7	+ 1·7	−0·3	− 7·1	−5·7	− 2·9	+3·3	+ 0·4
19	14	49	+ 4·7	−0·3	− 6·6	−2·2	− 5·0	+1·3	− 3·7
20	16	54	+ 9·0	−0·3	− 5·8	+2·9	+ 1·5	−0·9	+ 0·6
22	15	2	+ 5·4	−0·3	− 3·5	+1·6	+ 4·5	−4·4	+ 0·1
23	15	29	− 2·7	−0·3	− 1·0	−4·0	+ 1·6	−5·5	− 3·9
25	16	36	− 7·3	−0·3	+ 6·6	−1·0	+ 6·3	−5·3	+ 1·0
May 3	8	10	0·0	−0·3	− 6·5	−6·8	0·0	+0·8	+ 0·8
4	8	17	+ 5·8	−0·3	− 11·0	−5·5	− 1·0	+2·2	+ 1·2
8	7	18	+ 9·7	−0·3	− 18·1	−8·7	− 8·3	+8·4	+ 0·1
9	8	22	+ 16·0	−0·3	− 18·5	−2·8	− 11·3	+9·3	− 2·0
10	6	58	+ 12·7	−0·3	− 18·0	−5·6	− 10·7	+9·2	− 1·5
11	10	2	+ 10·6	−0·3	− 16·5	−6·2	− 7·7	+8·3	+ 0·6
12	11	36	+ 9·8	−0·3	− 13·6	−4·1	− 3·7	+6·8	+ 3·1
13	9	32	+ 5·5	−0·3	− 11·4	−6·2	− 2·0	+5·5	+ 3·5
14	8	19	+ 8·5	−0·3	− 9·5	−1·3	− 4·9	+4·4	− 0·5
15	9	47	+ 7·4	−0·3	− 8·7	−1·6	− 2·7	+3·1	+ 0·4
16	12	14	+ 5·5	−0·3	− 8·5	−3·3	− 4·7	+1·8	− 2·9
17	11	24	+ 5·7	−0·3	− 9·6	−4·2	− 6·6	+0·7	− 5·9
18	13	4	+ 10·6	−0·4	− 7·9	+2·4	+ 3·2	−0·6	+ 2·6
19	13	37	+ 4·4	−0·3	− 6·2	−2·1	+ 4·8	−1·9	+ 2·9
21	14	40	+ 2·7	−0·3	− 3·0	−0·6	+ 4·3	−4·3	0·0
22	15	16	+ 2·1	−0·3	− 2·0	−0·2	+ 4·3	−4·8	− 0·5
26	15	40	− 4·6	−0·3	+ 6·6	+1·7	+ 4·1	−4·2	− 0·1

Approx. G.M.T. 1851.			Longitude.			E.N.P.D.		
		B−0	Corr. to B.	H−B	H−0	B−0	H−B	H−0
	d h m		"	"	"	"	"	"
June 1	8 50	+ 18·4	−0·3	− 20·4	−2·3	−0·7	+0·8	+0·1
2	8 45	+ 23·0	−0·3	− 23·2	−0·5	−1·0	+2·6	+1·6
4	8 52	+ 15·0	−0·3	− 20·7	−6·0	−1·7	+6·1	+4·4
5	9 45	+ 11·7	−0·3	− 17·9	−6·5	−6·3	+6·8	+0·5
6	7 53	+ 8·9	−0·3	− 15·5	−6·9	−8·3	+6·9	−1·4
7	9 30	+ 10·5	−0·3	− 14·7	−4·5	−4·3	+6·0	+1·7
8	7 17	+ 9·3	−0·3	− 14·3	−5·3	−8·2	+4·8	−3·4
9	10 43	+ 10·7	−0·3	− 13·6	−3·2	−1·3	+2·8	+1·5
12	10 17	+ 8·2	−0·3	− 9·7	−1·8	−0·3	−1·0	−1·3
13	12 26	+ 12 5	−0·3	− 9·3	+2·9	+3·6	−1·3	+2·3
14	12 26	+ 8·5	−0·3	− 9·0	−0·8	+4·8	−1·5	+3·3
16	11 33	+ 9·6	−0·3	− 5·8	+3·5	+0·8	−1·3	−0·5
17	12 21	− 0·2	−0·3	− 3·1	−3·6	−1·3	−1·1	−2·4
18	15 6	+ 2·6	−0·3	− 1·1	+1·2	+3·8	−1·0	+2·8
19	14 25	− 1·4	−0 3	− 0·5	−2·2	−4·0	−0·9	−4·9
20	14 19	+ 3·9	−0·3	− 0·9	+2·7	+2·3	−0·9	+1·4
22	15 25	+ 2·6	−0·3	− 2·0	+0·3	+1·1	−1·1	0·0
23	15 42	+ 6·6	−0·3	− 1·8	+4·5	+4·6	−1·5	+3·1
24	15 51	+ 2·7	−0·3	− 1·8	+0·6	−1·6	−1·9	−3·5
25	15 11	+ 1·7	−0·3	− 3·4	−2·0	−1·3	−2·0	−3·3
July 2	8 29	+ 24·6	−0·3	− 32·3	−8·0	−1·1	+4·8	+3·7
4	8 39	+ 17·0	−0·3	− 20·8	−4·1	−3·9	+4·6	+0·7
5	8 51	+ 8·1	−0·3	− 15·5	−7·7	−0·5	+3·6	+3·1
6	9 4	+ 5·9	−0·3 ·	− 12·0	−6·4	+3·2	+2·1	+5·3
9	7 9	+ 4·8	−0·3	− 8·3	−3·8	−0·1	−2·1	−2·2
10	7 47	+ 6·1	−0 3	− 7·5	−1·7	+0·1	−3·1	−3·0
12	9 18	+ 11·3	−0·3	− 7·4	+3·6	+4·7	−3·4	+1·3
13	10 11	+ 8·9	−0·3	− 7·0	+1·6	+2·8	−2·8	0·0
14	10 59	+ 1·4	−0·3	− 5·8	−4·7	−0·8	−1·7	−2·5
15	11 58	+ 0·8	−0·3	− 3·5	−3·0	+0·7	−0·6	+0·1
16	12 18	− 3·5	−0·3	− 0·9	−4·7	−4·2	+0·7	−3·5
17	12 59	− 3·2	−0·3	+ 0·6	−2·9	−2·8	+1·6	−1·2
18	12 23	− 4·6	−0·3	+ 0·9	−4·0	−6·1	+2·2	−3·9
20	13 50	+ 2·0	−0·3	− 2·6	−0·9	−1·9	+2·3	+0·4
21	13 26	+ 4·0	−0·3	− 4·5	−0·8	−3·3	+2·2	−1·1
Aug. 3	8 35	+ 17·2	−0·3	− 16·5	+0·4	−0·8	+3·1	+2·3
5	6 22	+ 9·2	−0·3	− 8·3	+0·6	−1·2	+0·4	−0·8
7	7 43	+ 6·9	−0·3	− 4·0	+2·6	+2·3	−2·1	+0·2
8	8 23	+ 3·8	−0·3	− 3·2	+0·3	+2·6	−2·7	−0·1
10	9 3	+ 5·1	−0·3	− 4·3	+0·5	+1·6	−2·7	−1·1
11	9 16	+ 14·5	−0·3	− 5·5	+8·7	−1·1	−1·9	−3·0
12	10 16	+ 8·8	−0·3	− 6·0	+2·5	−0·8	−0·7	−1·5

Errors of Hansen's Tables deduced

Approx. G.M.T. 1851.			Longitude.				E.N.P.D.		
			B−O	Corr. to B.	H−B	H−O	B−O	H−B	H−O
d	h	m							
Aug. 13	9	57	+ 8ʺ9	−0ʺ3	− 5ʺ4	+ 3ʺ2	− 2ʺ1	+ 0ʺ9	− 1ʺ2
14	12	29	+ 9·6	−0·3	− 3·9	+ 5·4	− 1·4	+ 2·0	+ 0·6
15	11	6	+ 5·0	−0·3	− 2·2	+ 2·5	− 7·0	+ 2·8	− 4·2
16	17	47	+ 5·4	−0·3	− 1·7	+ 3·4	+ 1·6	+ 3·3	+ 4·9
17	11	42	+ 5·1	−0·3	− 2·4	+ 2·4	− 5·7	+ 3·5	− 2·2
18	11	18	+ 5·9	−0·3	− 4·5	+ 1·1	− 7·3	+ 3·4	− 3·9
19	11	45	+ 6·9	−0·3	− 7·3	− 0·7	− 5·7	+ 3·6	− 2·1
20	13	13	+11·1	−0·3	− 9·4	+ 1·4	− 7·3	+ 4·0	− 3·3
21	13	38	+ 10·3	−0·3	−10·1	− 0·1	− 9·7	+ 4·3	− 5·4
22	14	24	+ 8·0	−0·3	− 9·4	− 1·7	− 9·9	+ 5·2	− 4·7
23	15	14	+ 3·7	−0·3	− 9·1	− 5·7	− 7·8	+ 5·8	− 2·0
24	15	55	+ 5·3	−0·3	−12·1	− 7·1	− 8·9	+ 6·8	− 2·1
29	7	25	+37·4	−0·3	−38·7	− 1·6	− 5·3	+ 7·0	+ 1·7
31	5	36	+24·4	−0·3	−26·2	− 2·1	− 2·4	+ 4·4	+ 2·0
Sept. 1	7	9	+18·8	−0·3	−18·5	0·0	− 1·3	+ 3·1	+ 1·8
2	7	31	+ 8·7	−0·3	−12·6	− 4·2	− 2·4	+ 1·9	− 0·5
3	6	10	+ 9·5	−0·3	− 8·3	+ 0·9	− 5·0	+ 0·6	− 4·4
5	10	11	+ 5·6	−0·3	− 3·1	+ 2·2	+ 0·2	− 1·7	− 1·5
8	8	45	+ 3·3	−0·3	− 4·0	− 1·0	− 0·7	− 1·2	− 1·9
9	8	28	+ 8·9	−0·3	− 6·5	+ 2·1	− 3·9	− 0·7	− 4·6
10	8	21	+ 9·9	−0·3	− 8·8	+ 0·8	− 0·8	+ 0·5	− 0·3
11	8	36	+11·4	−0·3	−10·0	+ 1·1	− 3·2	+ 1·7	− 1·5
12	8	49	+ 8·3	−0·3	− 9·5	− 1·5	− 4·2	+ 2·6	− 1·6
13	9	26	+ 8·6	−0·3	− 8·1	+ 0·2	− 8·6	+ 3·1	− 5·5
14	11	8	+ 5·9	−0·3	− 7·0	− 1·4	− 3·6	+ 3·4	− 0·2
15	10	0	+ 8·8	−0·3	− 6·8	+ 1·7	− 6·5	+ 3·3	− 3·2
17	14	26	+10·7	−0·3	−11·4	− 1·0	− 7·5	+ 4·0	− 3·5
18	12	6	+12·8	−0·3	−13·3	− 0·8	− 6·9	+ 4·8	− 2·1
21	15	38	+ 8·0	−0·3	−12·4	− 4·7	−10·9	+ 7·3	− 3·6
22	16	3	+15·4	−0·3	−14·1	+ 1·0	−13·2	+ 7·6	− 5·6
28	6	27	+41·4	−0·3	−34·1	+ 7·0	− 2·9	+ 1·9	− 1·0
29	5	35	+28·6	−0·3	−27·0	+ 1·3	+ 5·6	+ 0·6	+ 6·2
30	5	31	+18·8	−0·3	−19·4	− 0·9	+ 2·2	− 0·4	+ 1·8
Oct. 2	6	1	+10·6	−0·3	− 8·2	+ 2·1	+ 1·8	− 2·4	− 0·6
3	7	37	+ 5·5	−0·3	− 5·4	− 0·2	+ 3·5	− 2·9	+ 0·6
4	7	1	+ 9·3	−0·3	− 4·4	+ 4·6	+ 1·0	− 3·0	− 2·0
5	6	14	+10·0	−0·3	− 5·2	+ 4·5	+ 1·5	− 2·7	− 1·2
6	7	29	+12·9	−0·3	− 7·3	+ 5·3	+ 2·8	− 1·9	+ 0·9
7	7	19	+ 8·2	−0·3	− 8·3	− 0·4	− 1·3	− 1·0	− 2·3
8	7	1	+17·4	−0·3	− 9·8	+ 7·3	− 3·7	+ 0·2	− 3·5
9	10	21	+18·1	−0·3	−12·1	+ 5·7	− 1·0	+ 1·5	+ 0·5
10	7	48	+16·1	−0·3	−13·3	+ 2·5	− 6·3	+ 2·3	− 4·0

Approx. G.M.T. 1851.			B−0	Longitude. Corr. to B.	H−B	H−0	E.N.P.D. B−0	H−B	H−0
	d	h m	"	"	"	"	"	"	"
Oct.	11	7 41	+21·7	−0·3	−13·8	+ 7·6	− 4·4	+2·7	−1·7
	12	8 5	+17·5	−0·3	−13·1	+ 4·1	− 9·7	+3·1	−6·6
	13	19 51	+16·2	−0·3	−10·5	+ 5·4	+ 2·8	+3·1	+5·9
	14	8 27	+12·4	−0·3	− 9·7	+ 2·4	−12·1	+3·3	−8·8
	15	11 37	+11·0	−0·3	− 9·4	+ 1·3	− 5·8	+3·9	−1·9
	16	10 52	+ 6·0	−0·3	−11·4	− 5·7	− 7·9	+4·9	−3·0
	17	11 15	+ 7·7	−0·3	−14·2	− 6·8	−11·8	+6·2	−5·6
	18	17 54	+21·6	−0·3	−16·7	+ 4·6	− 9·9	+7·2	−2·7
	19	15 3	+17·2	−0·3	−17·0	− 0·1	−11·0	+7·2	−3·8
	26	5 37	+43·3	−0·3	−32·2	+10·8	+ 7·5	−2·8	+4·7
	29	5 50	+16·9	−0·3	−15·6	+ 1·0	+ 2·4	−4·8	−2·4
	30	5 43	+11·5	−0·3	− 9·6	+ 1·6	+ 5·1	−5·1	0·0
Nov.	1	6 1	− 1·5	−0·3	− 4·8	− 6·6	+ 5·4	−4·5	+0·9
	2	4 57	+ 6·5	−0·3	− 5·5	+ 0·7	+ 4·3	−3·8	+0·5
	3	5 52	+ 8·2	−0·3	− 7·2	+ 0·7	+ 1·4	−2·8	−1·4
	4	6 36	+ 7·2	−0·3	− 8·8	− 1·9	+ 1·5	−1·6	−0·1
	6	10 19	+12·8	−0·3	−11·0	+ 1·5	+ 5·2	+0·9	+6·1
	7	6 20	+18·9	−0·3	−12·3	+ 6·3	− 4·7	+1·5	−3·2
	10	12 4	+17·5	−0·3	−14·3	+ 2·9	− 3·1	+2·6	−0·5
	11	7 31	+13·5	−0·3	−12·2	+ 1·0	− 5·3	+3·0	−2·3
	12	8 49	+ 4·8	−0·3	− 9·1	− 4·6	− 8·4	+3·7	−4·7
	13	19 31	+ 7·6	−0·3	− 8·6	− 1·3	− 2·5	+5·3	+2·8
	14	10 4	+14·8	−0·3	− 9·7	+ 4·8	−10·7	+6·4	−4·3
	15	11 43	+10·0	−0·3	−13·7	− 4·0	− 9·9	+7·5	−2·4
	16	13 3	+13·1	−0·3	−17·3	− 4·5	−12·9	+7·5	−5·4
	17	14 14	+15·8	−0·3	−18·4	− 2·9	− 7·1	+6·2	−0·9
	18	15 30	+15·1	−0·3	−16·7	− 1·9	− 6·6	+3·9	−2·7
	19	17 8	+ 8·5	−0·3	−14·1	− 5·9	− 4·7	+1·2	−3·5
	25	5 27	+19·6	−0·3	−18·2	+ 1·1	+ 5·5	−6·1	−0·6
	29	4 35	+ 3·3	−0·3	− 3·5	− 0·5	+ 4·8	−3·5	+1·3
	30	3 57	+ 3·5	−0·3	− 3·1	+ 0·1	+ 0·9	−2·2	−1·3
Dec.	2	8 18	+ 9·3	−0·3	− 6·2	+ 2·8	+ 3·5	+0·3	+3·8
	3	10 40	+ 8·4	−0·3	− 7·5	+ 0·6	+ 7·5	+1·5	+9·0
	4	4 47	+14·1	−0·3	− 8·4	+ 5·4	− 1·2	+2·2	+1·0
	5	8 55	+12·3	−0·3	− 9·3	+ 2·7	− 3·8	+2·8	−1·0
	7	8 14	+15·0	−0·3	−12·8	+ 1·9	− 4·7	+3·1	−1·6
	8	6 48	+19·6	−0·3	−14·2	+ 5·1	− 7·5	+3·2	−4·3
	9	12 57	+17·2	−0·3	−13·8	+ 3·1	− 4·3	+3·7	−0·6
	10	10 1	+17·2	−0·3	−11·9	+ 5·0	−11·5	+4·3	−7·2
	11	9 8	+11·3	−0·3	− 9·9	+ 1·1	−11·9	+4·8	−7·1
	13	11 54	+14·5	−0·3	−12·4	+ 1·8	−11·3	+6·5	−4·8
	18	19 48	+20·8	−0·3	−12·0	+ 8·5	− 2·0	−2·3	−4·3
	26	5 5	+ 2·4	−0·3	− 4·6	− 2·5	+ 5·3	−3·1	+2·2
	28	5 13	+ 6·8	−0·3	− 2·2	+ 4·3	+ 5·0	0·0	+5·0
	30	4 40	+ 2·1	−0·3	− 3·4	− 1·6	− 4·1	+2·5	−1·6
	31	7 16	+ 1·1	−0·3	− 5·1	− 4·3	− 3·9	+3·6	−0·3

Errors of Hansen's Tables deduced

Approx. G.M.T. 1852			B–O	Longitude Corr. to B.	H–B	H–O	R.N.P.D. B–O	H–B	H–O
	d	h m							
Jan.	1	6 28	− 3ʺ·6	−0ʺ·3	− 6ʺ·4	−10ʺ·3	− 9ʺ·2	+4ʺ·5	−4ʺ·7
	2	6 26	+ 6·3	−0·3	− 7·6	− 1·6	− 4·8	+5·0	+0·2
	3	4 55	+10·8	−0·3	− 9·0	+ 1·5	− 7·4	+5·4	−2·0
	4	4 20	+ 9·1	−0·3	−10·8	− 2·0	− 1·3	+5·5	+4·2
	5	6 21	+13·2	−0·3	−12·5	+ 0·4	− 4·3	+5·7	+1·4
	6	5 9	+14·1	−0·3	−14·0	− 0·2	− 3·9	+5·8	+1·9
	7	6 17	+11·3	−0·3	−14·9	− 3·9	− 6·1	+5·9	−0·2
	8	18 1	+16·3	−0·3	−15·2	+ 0·8	− 2·6	+5·4	+2·8
	9	8 52	+12·0	−0·3	−15·1	− 3·4	− 7·6	+5·3	−2·3
	10	8 54	+ 9·4	−0·3	−15·8	− 6·7	− 5·0	+4·8	−0·2
	11	10 40	+16·9	−0·3	−16·7	− 0·1	− 3·9	+3·8	−0·1
	13	15 46	+24·5	−0·3	−18·6	+ 5·6	− 1·2	+0·3	−0·9
	15	17 19	+13·6	−0·3	−14·9	− 1·6	+ 3·1	−4·4	−1·3
	16	19 37	+ 7·9	−0·3	− 9·3	− 1·7	+ 5·7	−6·6	−0·9
	17	18 52	+ 0·3	−0·3	− 3·3	− 3·3	+ 7·5	−7·7	−0·2
	18	19 32	− 1·6	−0·3	+ 2·1	+ 0·2	+11·4	−8·1	+3·3
	23	5 5	+ 0·2	−0·3	0·0	− 0·1	+ 5·1	−3·6	+1·5
	25	4 49	+ 2·5	−0·3	− 0·2	+ 2·0	+ 3·9	0·0	+3·9
	26	4 53	+ 1·9	−0·3	− 0·1	+ 1·5	− 2·1	+1·6	−0·5
	27	9 59	+ 0·2	−0·3	− 1·1	− 1·2	− 1·2	+3·0	+1·8
	28	5 4	− 0·1	−0·3	− 2·6	− 3·0	− 5·3	+3·5	−1·8
	29	4 55	+ 5·4	−0·3	− 4·9	+ 0·2	− 5·2	+4·6	−0·6
	30	5 24	+ 9·0	−0·3	− 7·7	+ 1·0	− 5·5	+5·1	−0·4
Feb.	1	3 52	+11·8•	−0·3	−11·3	+ 0·2	− 9·7	+6·0	−3·7
	2	10 23	+17·4	−0·3	−12·5	+ 4·6	− 3·8	+6·7	+2·9
	3	5 2	+14·2	−0·3	−13·0	+ 0·9	− 8·7	+6·6	−2·1
	5	11 51	+17·0	−0·3	−16·1	+ 0·6	− 7·4	+5·5	−1·9
	6	7 31	+12·8	−0·3	−17·2	− 4·7	− 8·8	+4·7	−4·1
	7	9 35	+15·4	−0·3	−17·1	− 2·0	− 4·0	+3·2	−0·8
	8	16 27	+14·5	−0·3	−15·3	− 1·1	+ 0·8	+1·2	+2·0
	9	11 43	+11·1	−0·3	−13·2	− 2·4	+ 0·1	0·0	+0·1
	10	13 10	+ 8·7	−0·3	−11·6	− 3·2	+ 1·2	−1·6	−0·4
	11	14 21	+ 8·7	−0·3	−11·0	− 2·6	+ 4·5	−3·6	+0·9
	22	6 20	− 6·8	−0·3	+ 3·4	− 3·7	− 1·4	−0·1	−1·5
	25	4 48	− 0·1	−0·3	− 0·8	− 1·2	− 2·6	+2·2	−0·4
	26	8 28	− 0·3	−0·3	− 3·8	− 4·4	− 3·9	+2·7	−1·2
	27	6 45	+ 8·0	−0·3	− 6·5	+ 1·2	− 3·4	+3·0	−0·4
	28	9 36	+11·6	−0·3	− 9·8	+ 1·5	− 2·7	+4·0	+1·3
	29	6 28	+ 9·8	−0·3	−11·6	− 2·1	− 2·6	+4·9	+2·3

Approx. G.M.T. 1852.			Longitude.				R.N.P.D.		
			B−O	Corr. to B.	H−B	H−O	B−O	H−B	H−O
	d	h m							
Mar. 1	5	40	+ 8″1	−0″3	− 12″8	− 5″0	− 8″7	+6″0	−2″7
2	4	10	+ 9·3	−0·3	− 12·8	− 3·8	− 8·7	+6·7	−2·0
3	7	7	+ 8·3	−0·3	− 12·4	− 4·4	− 8·6	+6·9	−1·7
4	6	7	+10·1	−0·3	− 12·9	− 3·1	− 9·5	+6·3	−3·2
5	6	49	+13·6	−0·3	− 14·0	− 0·7	− 8·3	+5·0	−3·3
6	7	56	+12·9	−0·3	− 15·0	− 2·4	− 7·9	+3·4	−4·5
7	9	44	+11·0	−0·3	− 13·8	− 3·1	− 6·1	+1·4	−4·7
14	17	42	0·0	−0·3	+ 5·9	+ 5·6	+ 5·6	−7·1	−1·5
22	7	11	− 7·3	−0·3	+ 5·5	− 2·1	+ 0·6	+1·5	+2·1
23	6	44	+ 0·7	−0·3	+ 1·8	+ 2·2	+ 2·1	+1·9	+4·0
25	6	39	+ 6·6	−0·3	− 4·1	+ 2·2	+ 0·7	+2·4	+3·1
26	8	24	+ 4·9	−0·3	− 6·7	− 2·1	− 1·3	+2·9	+1·6
27	7	24	+11·3	−0·3	− 8·8	+ 2·2	− 2·3	+3·7	+1·4
28	7	6	+18·2	−0·3	− 10·7	+ 7·2	− 6·9	+4·7	−2·2
30	8	15	+14·5	−0·3	− 13·5	+ 0·7	− 4·6	+7·5	+2·9
Apr. 1	6	33	+14·9	−0·3	− 13·3	+ 1·3	− 11·6	+8·1	−3·5
2	6	47	+11·8	−0·3	− 12·7	− 1·2	− 9·1	+7·2	−1·9
3	7	6	+10·8	−0·3	− 12·8	− 2·3	− 4·2	+5·9	+1·7
4	8	13	+ 8·2	−0·3	− 12·7	− 4·8	− 5·7	+4·1	−1·6
5	9	31	+ 8·6	−0·3	− 12·6	− 4·3	− 4·8	+2·3	−2·5
8	13	42	+ 4·2	−0·3	− 3·6	+ 0·3	− 0·8	−2·0	−2·8
9	15	4	− 0·5	−0·3	− 0·9	− 1·7	+ 4·1	−3·5	+0·6
10	15	28	− 2·4	−0·3	+ 0·9	− 1·8	+ 5·3	−4·5	+0·8
13	16	57	− 2·4	−0·3	+ 7·9	+ 5·2	+ 3·1	−3·7	−0·6
21	7	55	− 2·6	−0·3	− 1·9	− 4·8	− 1·7	+2·8	+1·1
22	7	41	+11·5	−0·3	− 6·3	+ 4·9	+ 2·8	+3·3	+6·1
24	7	39	+12·6	−0·3	− 10·2	+ 2·1	− 4·0	+4·6	+0·6
25	7	35	+12·0	−0·3	− 11·2	+ 0·5	− 6·5	+5·6	−0·9
26	7	15	+11·8	−0·3	− 12·1	− 0·6	− 11·7	+6·9	−4·8
27	8	8	+14·9	−0·3	− 13·8	+ 0·8	− 7·8	+7·9	+0·1
29	10	34	+ 6·4	−0·3	− 15·5	− 9·4	− 11·7	+8·2	−3·5
May 1	8	40	+15·7	−0·3	− 12·8	+ 2·6	− 6·3	+5·6	−0·7
2	7	31	+ 8·9	−0·3	− 12·4	− 3·8	− 3·1	+4·1	+1·0
3	8	55	+11·5	−0·3	− 13·1	− 1·9	+ 0·6	+2·4	+3·0
4	9	22	+ 7·6	−0·3	− 14·1	− 6·8	− 0·9	+1·1	+0·2
5	11	22	+11·9	−0·3	− 13·3	− 1·7	− 3·7	−0·2	−3·9
10	15	53	+ 5·8	−0·3	− 1·3	+ 4·2	+ 2·4	−2·3	+0·1
22	8	30	+ 9·9	−0·3	− 13·2	− 3·6	+ 0·8	+3·9	+4·7
29	11	58	+ 6·2	−0·3	− 12·7	− 6·8	+ 1·3	+1·5	+2·8
31	8	52	+ 5·8	−0·3	− 11·3	− 5·8	− 0·3	−1·3	−1·6
June 1	9	24	+12·8	−0·3	− 12·4	+ 0·1	+ 0·3	−2·5	−2·2

Errors of Hansen's Tables deduced

Approx. G.M.T. 1852.			Longitude.				E.N.P.D.		
			B−O	Corr. to B.	H−B	H−O	B−O	H−B	H−O
	d	h	m							
June 2	9	33	+ 6·1	−0·3	− 12·7	−6·9	−1·4	−3·1	−4·5
4	12	38	+ 8·5	−0·3	− 9·2	−1·0	−1·0	−3·0	−4·0
10	14	43	+ 4·8	−0·3	− 2·8	+1·7	−9·2	+3·4	−5·8
11	15	9	+ 3·6	−0·3	− 1·1	+2·2	−5·9	+3·9	−2·0
19	9	18	+14·5	−0·3	−16·9	−2·7	−4·5	+2·5	−2·0
21	8	42	+16·1	−0·3	−19·5	−3·7	−0·7	+3·0	+2·3
22	7	59	+13·0	−0·3	−19·3	−6·6	−1·7	+2·8	+1·1
23	8	3	+13·5	−0·3	−18·2	−5·0	−0·1	+2·5	+2·4
24	8	42	+11·1	−0·3	−16·3	−5·5	−0·6	+1·8	+1·2
26	8	37	+10·6	−0·3	−12·2	−1·9	+1·5	−1·0	+0·5
27	6	55	+ 4·0	−0·3	−11·0	−7·3	+1·1	−2·5	−1·4
29	9	13	+ 6·5	−0·3	− 9·7	−3·5	+4·7	−5·6	−0·9
30	9	3	+11·4	−0·3	− 8·6	+2·5	+9·3	−6·2	+3·1
July 1	10	11	+ 6·0	−0·3	− 7·9	−2·2	+7·6	−6·0	+1·6
2	11	25	+ 4·9	−0·3	− 6·9	−2·3	+4·7	−5·2	−0·5
3	11	21	+ 6·2	−0·3	− 6·3	−0·4	+3·8	−4·0	−0·2
4	12	0	+ 8·5	−0·3	− 5·6	+2·6	+0·1	−2·1	−2·0
5	11	48	+ 7·9	−0·3	− 4·6	+3·0	−1·9	0·0	−1·9
6	12	8	+ 3·9	−0·3	− 3·3	+0·3	−5·6	+1·4	−4·2
7	12	29	+ 0·8	−0·3	− 2·5	−2·0	−7·2	+2·6	−4·6
8	13	37	− 0·6	−0·3	− 1·9	−2·8	−6·0	+3·8	−2·2
9	12	55	+ 5·0	−0·3	− 2·1	+2·6	−9·4	+4·6	−4·8
10	14	14	+ 6·2	−0·3	− 1·9	+4·0	−6·3	+4·7	−1·6
20	8	15	+25·4	−0·3	−28·3	−3·2	+1·3	+3·2	+4·5
21	7	52	+19·2	−0·3	−24·8	−5·9	+0·6	+2·9	+3·5
22	7	28	+11·9	−0·3	−20·2	−8·6	+5·5	+2·6	+8·1
23	7	41	+ 6·8	−0·3	−15·4	−8·9	+4·8	+1·8	+6·6
24	9	3	+ 5·2	−0·3	−12·1	−7·2	+1·3	+0·7	+2·0
27	7	6	+ 7·4	−0·3	−10·1	−3·0	+4·1	−4·3	−0·2
29	8	28	+12·2	−0·3	− 9·3	+2·6	+5·6	−6·0	−0·4
30	9	18	+11·3	−0·3	− 9·5	+1·5	+3·5	−5·9	−2·4
31	11	54	+ 9·9	−0·3	− 9·8	−0·2	+6·4	−4·6	+1·8
Aug. 1	11	31	+10·0	−0·3	− 9·7	0·0	+2·8	−3·0	−0·2
2	10	27	+11·8	−0·3	− 8·2	+3·3	+0·2	−1·3	−1·1
3	11	12	+ 5·9	−0·3	− 4·9	+0·7	−4·5	+0·4	−4·1
4	11	6	+ 3·9	−0·3	− 1·6	+2·0	−5·2	+1·7	−3·5
5	11	22	− 1·6	−0·3	+ 0·3	−1·6	−6·4	+2·6	−3·8
6	11	37	+ 4·1	−0·3	+ 0·4	+4·2	−6·6	+3·1	−3·5
7	11	54	+ 8·9	−0·3	− 0·6	+8·0	−7·6	+3·8	−3·8
8	12	46	+ 6·3	−0·3	− 2·1	+3·9	−8·6	+4·3	−4·3
9	12	58	+ 0·6	−0·3	− 2·6	−2·3	−9·4	+5·1	−4·3
10	14	30	+ 3·7	−0·3	− 3·1	+0·3	−7·1	+5·6	−1·5

Approx. G.M.T. 1852.			Longitude.				E.N.P.D.		
			B−O	Corr. to B.	H−B	H−O	B−O	H−B	H−O
d	h	m	″	″	″	″	″	″	″
Aug. 18	8	17	+35·4	−0·3	−35·6	−0·5	− 5·1	+4·4	− 0·7
19	8	11	+25·9	−0·3	−29·0	−3·4	− 3·3	+3·6	+ 0·3
21	7	44	+ 7·9	−0·3	−14·6	−7·0	+ 0·3	+2·5	+ 2·8
22	7	47	+10·4	−0·3	−10·3	−0·2	+ 0·1	+1·4	+ 1·5
25	7	39	+ 7·0	−0·3	− 7·7	−1·0	+ 2·8	−3·0	− 0·2
26	8	0	+11·3	−0·3	− 8·8	+2·2	+ 6·0	−3·5	+ 2·5
27	7	59	+14·3	−0·3	−10·7	+3·3	+ 3·1	−3·4	− 0·3
28	8	31	+17·6	−0·3	−13·1	+4·2	+ 3·9	−3·0	+ 0·9
29	8	55	+13·7	−0·3	−15·0	−1·6	− 0·4	−1·8	− 2·2
30	8	51	+16·1	−0·3	−15·0	+0·8	− 3·4	−0·3	− 3·7
31	9	17	+ 8·2·	−0·3	−12·3	−4·4	− 4·9	+0·8	− 4·1
Sept. 1	10	23	+10·3	−0·3	− 7·6	+2·4	− 2·7	+1·6	− 1·1
2	9	52	+ 4·3	−0·3	− 3·4	+0·6	− 4·6	+2·2	− 2·4
3	10	19	+ 1·9	−0·3	− 0·2	+1·4	− 6·2	+2·5	− 3·7
4	11	30	+ 7·2	−0·3	+ 0·5	+7·4	− 6·3	+2·9	− 3·4
5	11	32	+ 5·9	−0·3	− 1·3	+4·3	− 6·2	+4·0	− 2·2
7	16	39	+ 7·0	−0·3	− 7·1	−0·4	−10·1	+7·0	− 3·1
8	13	51	+ 6·3	−0·3	− 8·9	−2·9	−12·2	+8·1	− 4·1
11	16	47	+13·5	−0·3	−21·6	−8·4	−10·9	+9·1	− 1·8
16	6	37	+37·0	−0·3	−41·1	−4·4	− 3·5	+2·4	− 1·1
17	6	45	+33·9	−0·3	−33·5	+0·1	− 3·3	+1·1	− 2·2
18	7	39	+25·2	−0·3	−23·9	+1·0	− 3·4	−0·2	− 3·6
20	8	56	+ 9·3	−0·3	− 9·9	−0·9	+ 5·5	−2·4	+ 3·1
21	7	56	+ 9·5	−0·3	− 6·9	+2·3	+ 0·7	−3·2	− 2·5
22	9	20	+ 7·8	−0·3	− 5·5	+2·0	+ 1·9	−3·4	− 1·5
23	6	47	+ 6·4	−0·3	− 5·6	+0·5	+ 7·5	−3·1	+ 4·4
24 .	6	45	+ 8·6	−0·3	− 6·8	+1·5	+ 2·4	−2·3	+ 0·1
25	7	11	+12·5	−0·3	− 9·0	+3·2	+ 1·8	−1·2	+ 0·6
26	8	23	+13·2	−0·3	−12·0	+0·9	+ 1·2	+0·2	+ 1·4
28	8	48	+15·0	−0·3	−15·1	−0·4	− 6·2	+2·6	− 3·6
29	7	46	+13·1	−0·3	−13·7	−0·9	− 4·9	+3·2	− 1·7
30	8	5	+10·3	−0·3	−10·6	−0·6	− 7·9	+3·5	− 4·4
Oct. 2	9	40	+ 1·1	−0·3	− 3·4	−2·6	− 9·6	+3·9	− 5·7
3	9	25	+ 2·1	−0·3	− 2·3	−0·5	− 8·5	+4·3	− 4·2
4	12	40	+ 9·7	−0·3	− 3·9	+5·5	− 8·4	+5·3	− 3·1
5	10	33	+ 8·6	−0·3	− 6·7	+1·6	− 8·1	+6·6	− 1·5
6	11	59	+ 4·3	−0·3	−11·7	−7·7	−11·4	+8·4	− 3·0
8	14	38	+11·1	−0·3	−18·8	−8·0	−10·0	+9·4	− 0·6
11	17	35	+26·2	−0·3	−28·7	−2·8	−14·5	+4·8	− 9·7
15	6	0	+41·1	−0·3	−38·4	+2·4	− 7·4	−3·3	−10·7
17	6	15	+23·3	−0·3	−24·1	−1·1	+ 4·6	−6·1	− 1·5
18	6	59	+ 7·6	−0·3	−16·6	−9·3	+ 4·8	−6·9	− 2·1

Errors of Hansen's Tables deduced

Approx. G.M.T. 1852.			Longitude.				R.N.P.D.		
			B−O	Corr. to B.	H−B	H−O	B−O	H−B	H−O
	d	h m							
Oct. 19	6	46	+ 7ʺ2	−0ʺ3	−11ʺ6	− 4ʺ7	+ 4ʺ5	−6ʺ9	−2ʺ4
20	5	4	+ 6·3	−0·3	− 9·0	− 3·0	+ 5·3	−6·3	−1·0
21	8	49	+ 7·9	−0·3	− 7·5	+ 0·1	+ 5·1	−4·9	+0·2
22	6	58	+ 8·1	−0·3	− 7·2	+ 0·6	+ 0·9	−3·3	−2·4
23	6	52	+ 8·2	−0·3	− 7·2	+ 0·7	− 0·1	−1·4	−1·5
24	7	1	+ 6·5	−0·3	− 7·4	− 1·2	− 1·9	+0·2	−1·7
25	7	51	+11·1	−0·3	− 8·2	+ 2·6	− 0·6	+1·7	+1·1
26	7	24	+10·9	−0·3	− 9·6	+ 1·0	− 6·1	+3·0	−3·1
27	10	50	+11·4	−0·3	−11·5	− 0·4	− 6·2	+3·9	−2·3
28	8	57	+17·3	−0·3	−12·4	+ 4·6	− 3·5	+4·1	+0·6
29	11	45	+13·3	−0·3	−11·8	+ 1·2	− 3·7	+4·0	+0·3
30	16	50	+13·8	−0·3	− 9·3	+ 4·2	− 0·7	+3·9	+3·2
31	9	1	+10·6	−0·3	− 7·5	+ 2·8	− 7·0	+4·1	−2·9
Nov. 2	9	47	+10·2	−0·3	− 5·8	+ 4·1	−11·1	+5·2	−5·9
3	10	24	+ 2·6	−0·3	− 8·6	− 6·3	−10·4	+6·0	−4·4
5	14	23	+15·8	−0·3	−17·6	− 2·1	−13·0	+6·7	−6·3
7	15	36	+16·3	−0·3	−18·4	− 2·4	−11·3	+4·1	−7·2
16	5	31	+12·0	−0·3	−13·8	− 2·1	+ 9·0	−7·6	+1·4
17	8	15	+ 8·2	−0·3	−10·5	− 2·6	+ 7·7	−6·0	+1·7
18	4	45	+ 7·5	−0·3	− 9·7	− 2·5	+ 3·5	−4·5	−1·0
19	9	59	+ 4·7	−0·3	− 9·2	− 4·8	+ 2·2	−1·9	+0·3
20	6	7	+14·3	−0·3	− 9·1	+ 4·9	+ 0·2	0·0	+0·2
24	7	30	+ 7·1	−0·3	− 6·6	+ 0·2	− 6·5	+4·9	−1·6
26	10	39	+11·2	−0·3	− 9·0	+ 1·9	− 7·5	+4·9	−2·6
27	6	29	+12·0	−0·3	− 9·7	+ 2·0	− 6·3	+4·7	−1·6
28	8	59	+10·6	−0·3	− 9·9	+ 0·4	− 6·1	+4·3	−1·8
29	15	6	+ 2·5	−0·3	− 8·0	− 5·8	− 3·2	+3·9	+0·7
30	11	33	− 4·5	−0·3	− 6·7	−11·5	− 5·1	+3·8	−1·3
Dec. 1	22	7	+12·7	−0·3	− 6·5	+ 5·9	− 2·0	+4·0	+2·0
2	15	44	+ 9·8	−0·3	− 7·8	+ 1·7	− 4·6	+4·3	−0·3
3	18	22	+10·5	−0·3	−11·0	− 0·8	− 6·0	+4·0	−2·0
15	5	22	+10·7	−0·3	− 8·6	+ 1·8	+ 6·6	−5·0	+1·6
17	5	1	+10·6	−0·3	− 6·9	+ 3·4	+ 1·9	−0·5	+1·4
18	4	37	+ 5·7	−0·3	− 7·4	− 2·0	− 3·5	+1·6	−1·9
19	8	16	+ 4·8	−0·3	− 8·3	− 3·8	− 2·8	+3·8	+1·0
20	4	16	+11·3	−0·3	− 8·9	+ 2·1	− 5·7	+5·3	−0·4
21	4	39	+16·2	−0·3	− 8·9	+ 7·0	− 3·5	+6·4	+2·9
22	7	6	+ 3·2	−0·3	− 7·5	− 4·6	− 4·0	+7·2	+3·2
24	4	57	+ 6·6	−0·3	− 5·6	+ 0·7	− 9·2	+7·1	−2·1
25	12	22	+ 5·6	−0·3	− 6·3	− 1·0	− 8·2	+6·5	−1·7
26	5	11	+ 7·6	−0·3	− 7·4	− 0·1	− 5·6	+6·3	+0·7
27	7	12	+10·1	−0·3	− 8·6	+ 1·2	− 8·3	+5·7	−2·6

Approx. G.M.T. 1852			Longitude.				E.N.P.D.		
			B−O	Corr. to B.	H−B	H−O	B−O	H−B	H−O
Dec.	d	h m							
28	7	42	−0″.8	−0″.3	−8″.7	− 9″.8	−3″.9	+5″.0	+1″.1
29	9	12	+2.1	−0.3	−7.8	− 6.0	−4.4	+4.4	0.0
30	9	14	−3.8	−0.3	−7.4	−11.5	−3.9	+4.0	+0.1
31	10	33	+3.9	−0.3	−8.0	− 4.4	−6.5	+3.6	−2.9

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Errors of Hansen's Tables deduced

Approx. G.M.T. 1853.			B−O	Corr. to B.	Longitude. H−B	H−O	R.N.P.D. B−O	H−B	H−O
Jan. d	h	m							
1	19	34	+ 6ʹʹ4	−0ʹʹ3	− 10ʹʹ7	−4ʹʹ6	− 2ʹʹ1	+2ʹʹ7	+ 0ʹʹ6
3	15	50	+ 4·3	−0·3	− 10·7	−6·7	− 0·1	−0·2	− 0·3
4	16	43	+ 3·3	−0·3	− 7·4	−4·4	+ 1·4	−2·2	− 0·8
5	18	10	− 0·8	−0·3	− 2·3	−3·4	+ 4·8	−4·0	+ 0·8
13	4	42	+ 4·2	−0·3	− 3·6	+0·3	+ 5·7	−3·3	+ 2·4
15	6	7	+ 6·7	−0·3	− 3·8	+2·6	+ 1·2	+0·8	+ 2·0
16	8	54	+ 0·9	−0·3	− 5·4	−4·8	+ 0·7	+3·0	+ 3·7
18	4	14	+10·5	−0·3	− 8·8	+1·4	− 5·9	+5·7	− 0·2
19	10	25	+11·5	−0·3	− 9·0	+2·2	− 3·2	+7·0	+ 3·8
20	5	12	+10·2	−0·3	− 8·1	+1·8	−11·2	+7·5	− 3·7
21	7	42	+ 8·6	−0·3	− 6·0	+2·3	− 8·9	+7·9	− 1·0
22	4	38	+ 4·3	−0·3	− 4·8	−0·8	−10·4	+7·9	− 2·5
23	5	35	+ 2·8	−0·3	− 4·8	−2·3	− 6·9	+7·6	+ 0·7
24	11	27	+ 4·0	−0·3	− 6·8	−3·1	− 6·0	+6·6	+ 0·6
25	9	3	+ 5·8	−0·3	− 8·6	−3·1	− 7·9	+6·1	− 1·8
26	9	11	+10·3	−0·3	− 9·6	+0·4	− 4·3	+5·0	+ 0·7
27	11	47	+ 5·0	−0·3	− 9·8	−5·1	− 3·7	+3·8	+ 0·1
30	18	17	+ 5·5	−0·3	− 13·0	−7·8	+ 1·5	+0·2	+ 1·7
Feb. 1	19	40	+ 5·9	−0·3	− 12·8	−7·2	− 7·5	−3·9	−11·4
11	6	17	+ 0·2	−0·3	+ 1·4	+1·3	+ 8·6	−2·0	+ 6·6
15	6	18	+ 8·7	−0·3	− 6·0	+2·4	− 3·0	+3·9	+ 0·9
16	7	51	+ 8·9	−0·3	− 7·5	+1·1	− 4·1	+5·2	+ 1·1
17	6	40	+ 5·8	−0·3	− 7·3	−1·8	− 6·5	+6·3	− 0·2
18	6	40	+ 6·7	−0·3	− 5·8	+0·6	− 8·5	+7·0	− 1·5
19	5	17	+ 5·8	−0·3	− 4·0	+1·5	− 9·1	+7·6	− 1·5
20	4	44	− 0·2	−0·3	− 2·7	−3·2	−11·4	+7·4	− 4·0
21	4	55	+ 2·6	−0·3	− 2·7	−0·4	− 9·1	+7·0	− 2·1
22	10	51	+ 3·5	−0·3	− 4·3	−1·1	− 6·9	+5·9	− 1·0
23	8	25	+ 4·8	−0·3	− 6·2	−1·7	− 6·2	+4·7	− 1·5
25	10	53	+ 7·9	−0·3	− 10·3	−2·7	− 0·3	+1·1	+ 0·8
27	11	58	+10·1	−0·3	− 12·6	−2·8	+ 1·0	−2·3	− 1·3
28	13	58	+10·5	−0·3	− 13·1	−2·9	+ 4·5	−4·4	+ 0·1
Mar. 3	18	7	+ 8·6	−0·3	− 7·5	+0·8	+11·4	−9·5	+ 1·9
11	6	31	− 5·5	−0·3	+ 6·2	+0·4	+10·2	−0·4	+ 9·8
12	6	23	− 1·7	−0·3	+ 3·1	+1·1	+ 5·9	+0·7	+ 6·6
13	6	23	+ 1·5	−0·3	+ 0·5	+1·7	+ 4·6	+1·7	+ 6·3
14	6	39	− 0·3	−0·3	− 1·5	−2·1	+ 1·1	+2·9	+ 4·0
15	6	19	+ 2·2	−0·3	− 3·1	−1·2	− 1·7	+3·9	+ 2·2

Approx. G.M.T. 1853.			Longitude.				E.N.P.D.		
			B–O	Corr. to B.	H–B	H–O	B–O	H–B	H–O
	d	h	m						
Mar. 17	8	50	+ 1ʺ8	−0ʺ3	− 5ʺ1	−3ʺ6	− 3ʺ6	+6ʺ5	+2ʺ9
18	5	44	+ 3·2	−0·3	− 4·9	−2·0	− 6·9	+7·4	+0·9
19	4	54	− 0·4	−0·3	− 4·0	−4·7	−10·2	+8·2	−2·0
20	6	29	− 5·4	−0·3	− 2·8	−8·5	− 5·3	+8·6	+3·3
21	10	40	+ 0·4	−0·3	− 1·7	−1·6	− 6·0	+8·1	+2·1
22	6	32	+ 3·4	−0·3	− 1·7	+1·4	− 8·4	+7·6	−0·8
23	6	9	− 3·5	−0·3	− 2·8	−6·6	− 7·6	+6·4	−1·2
24	7	50	+ 5·5	−0·3	− 5·3	−0·1	− 5·6	+4·4	−1·2
25	8	54	+ 7·9	−0·3	− 9·1	−1·5	− 3·8	+2·3	−1·5
26	9	14	+ 8·2	−0·3	−12·3	−4·4	− 1·5	−0·2	−1·7
27	13	23	+ 8·4	−0·3	−13·8	−5·7	+ 3·2	−3·0	+0·2
28	12	46	+ 8·4	−0·3	−12·7	−4·6	+ 3·9	−5·0	−1·1
29	14	30	+ 5·9	−0·3	−10·1	−4·5	+ 5·4	−7·2	−1·8
30	16	7	+ 4·2	−0·3	− 7·6	−3·7	+ 9·3	−8·7	+0·6
31	18	0	+ 8·3	−0·3	− 5·5	+2·5	+ 7·0	−9·4	−2·4
Apr. 1	17	18	+ 1·2	−0·3	− 3·2	−2·3	+ 8·3	−9·0	−0·7
11	7	56	+ 7·3	−0·3	− 3·6	+3·4	+ 2·7	+4·5	+7·2
13	7	30	+ 3·2	−0·3	− 4·8	−1·9	− 0·6	+5·8	+5·2
14	7	51	+ 6·6	−0·3	− 4·7	+1·6	− 3·9	+6·9	+3·0
17	7	59	+ 4·4	−0·3	− 5·8	−1·7	−10·0	+9·0	−1·0
20	7	48	+ 2·7	−0·3	− 6·1	−3·7	− 7·9	+7·7	−0·2
23	10	3	+13·6	−0·3	−14·5	−1·2	− 5·9	+1·8	−4·1
25	12	39	+13·2	−0·3	−16·6	−3·7	+ 3·8	−3·3	+0·5
26	13	0	+13·6	−0·3	−12·9	+0·4	+ 2·3	−5·0	−2·7
May 10	8	17	+ 9·3	−0·3	− 7·9	+1·1	− 6·7	+5·1	−1·6
11	8	29	+ 9·3	−0·3	− 8·6	+0·4	− 3·9	+5·1	+1·2
13	7	57	+ 8·5	−0·3	− 8·8	−0·6	− 3·7	+5·3	+1·6
14	7	30	+ 9·5	−0·3	− 8·8	+0·4	− 6·6	+5·5	−1·1
15	8	1	+10·0	−0·3	− 9·2	+0·5	− 5·8	+5·9	+0·1
16	8	31	+ 4·4	−0·3	− 9·9	−5·8	− 2·5	+5·7	+3·2
17	8	37	+ 7·8	−0·3	−10·7	−3·2	− 5·4	+5·4	0·0
18	6	48	+ 7·1	−0·3	−11·0	−4·2	− 4·3	+4·8	+0·5
19	7	32	+ 4·6	−0·3	−11·4	−7·1	− 4·6	+3·7	−0·9
20	8	5	+ 8·9	−0·3	−12·3	−3·7	− 0·5	+2·3	+1·8
21	8	18	+10·8	−0·3	−14·3	−3·8	− 0·8	+0·6	−0·2
22	10	16	+15·5	−0·3	−16·8	−1·6	+ 3·0	−1·6	+1·4
23	10	23	+ 9·9	−0·3	−17·5	−7·9	+ 2·3	−3·5	−1·2
25	13	26	+10·8	−0·3	−12·7	−2·2	+ 7·2	−4·6	+2·6
26	14	38	+ 5·1	−0·3	− 9·0	−4·2	+ 7·4	−3·7	+3·7
27	15	44	+ 0·7	−0·3	− 6·2	−5·8	+ 1·1	−2·6	−1·5
28	16	53	− 1·9	−0·3	− 4·0	−6·2	+ 2·9	−0·8	+2·1

Errors of Hansen's Tables deduced

Approx. G.M.T. 1853			Longitude				R.N.P.D.		
			B−0	Corr. to B.	H−B	H−0	B−0	H−B	H−0
d	h	m	"	"	"	"	"	"	"
June 10	9	9	+ 9·4	−0·3	−13·5	−4·4	− 0·7	+3·5	+2·8
11	9	40	+17·2	−0·3	−14·0	+2·9	− 1·9	+2·7	+0·8
14	7	28	+ 9·1	−0·3	−13·1	−4·3	− 3·2	+1·6	−1·6
16	6	17	+ 6·6	−0·3	−12·9	−6·6	+ 0·1	−0·5	−0·4
17	6	51	+ 6·3	−0·3	−12·1	−6·1	− 0·2	−2·1	−2·3
18	7	16	+ 2·3	−0·3	−11·2	−9·2	+ 1·3	−3·8	−2·5
19	9	32	+ 6·0	−0·3	−10·7	−5·0	+ 8·4	−5·8	+2·6
21	10	5	+ 7·0	−0·3	−11·8	−5·1	+ 4·3	−7·7	−3·4
23	11	58	+12·9	−0·3	−11·1	+1·5	+ 4·6	−6·2	−1·6
28	19	42	+ 7·6	−0·3	− 3·4	+3·9	− 2·4	+4·1	+1·7
29	15	13	+ 8·2	−0·3	− 2·2	+5·7	− 2·4	+5·2	+2·8
30	14	43	+ 3·0	−0·3	− 0·8	+1·9	−10·9	+6·1	−4·8
July 9	8	10	+18·0	−0·3	−18·2	−0·5	− 0·7	+3·4	+2·7
10	9	36	+17·8	−0·3	−18·5	−1·0	− 0·9	+3·0	+2·1
12	8	19	+10·4	−0·3	−17·0	−6·9	+ 1·3	+2·2	+3·5
14	9	15	+ 6·3	−0·3	−15·4	−9·4	+ 1·7	0·0	+1·7
15	8	24	+ 8·1	−0·3	−13·9	−6·1	+ 3·0	−1·7	+1·3
17	8	56	+ 5·1	−0·3	− 9·6	−4·8	+ 7·9	−6·4	+1·5
18	9	12	+ 0·1	−0·3	− 9·0	−9·2	+10·0	−8·3	+1·7
19	10	42	+10·5	−0·3	−10·2	0·0	+ 8·4	−9·4	−1·0
22	13	39	+14·8	−0·3	−13·5	+1·0	+ 8·8	−7·4	+1·4
23	12	41	+19·2	−0·3	−12·2	+6·7	+ 8·5	−5·6	+2·9
24	14	29	+10·7	−0·3	−10·1	+0·3	+ 7·5	−3·5	+4·0
25	11	32	+ 9·9	−0·3	− 8·1	+1·5	− 0·2	−1·7	−1·9
26	14	56	+ 9·3	−0·3	− 6·1	+2·9	− 3·2	+0·2	−3·0
28	16	41	+10·3	−0·3	− 3·4	+6·6	− 2·4	+3·4	+1·0
30	13	49	+ 2·3	−0·3	− 0·4	+1·6	− 7·6	+5·6	−2·0
Aug. 7	8	20	+27·4	−0·3	−25·0	+2·1	−11·5	+5·3	−6·2
8	7	34	+19·9	−0·3	−23·8	−4·2	− 5·6	+5·0	−0·6
9	7	43	+17·9	−0·3	−21·7	−4·1	− 4·7	+4·9	+0·2
10	7	58	+11·5	−0·3	−19·3	−8·1	− 0·7	+4·4	+3·7
11	7	23	+15·3	−0·3	−17·0	−2·0	− 0·5	+3·3	+2·8
12	7	23	+ 6·9	−0·3	−14·8	−8·2	− 0·4	+1·6	+1·2
13	8	9	+ 8·8	−0·3	−12·9	−4·4	+ 0·4	−0·5	−0·1
17	9	8	+15·0	−0·3	−18·0	−3·3	+ 4·5	−6·6	−2·1
18	9	16	+22·2	−0·3	−20·0	+1·9	+ 6·9	−6·3	+0·6
20	10	29	+18·1	−0·3	−19·6	−1·8	+ 3·9	−4·8	−0·9
23	11	39	+12·2	−0·3	− 8·5	+3·4	+ 1·2	−1·3	−0·1
24	10	29	+10·3	−0·3	− 4·7	+5·3	− 1·5	−0·1	−1·6
25	14	10	+ 1·6	−0·3	− 2·3	−1·0	− 5·4	+1·4	−4·0
26	16	37	+ 3·6	−0·3	− 1·4	+1·9	− 6·7	+2·8	−3·9
27	12	18	+ 5·5	−0·3	− 1·2	+4·0	− 7·9	+3·9	+4·0

Approx. G.M.T. 1853.			B−O	Longitude. Corr. to B.	H−B	H−O	E.N.P.D. B−O	H−B	H−O
d	h	m	″	″	″	″	″	″	″
Aug. 28	12	39	+ 3·5	−0·3	− 2·1	+ 1·1	− 6·9	+ 5·4	− 1·5
29	13	53	+ 1·2	−0·3	− 4·3	−3·6	− 9·9	+ 6·7	− 3·2
30	16	20	+10·3	−0·3	− 8·7	+ 1·3	−10·0	+ 7·6	− 2·4
Sept. 5	7	5	+36·4	−0·3	−35·7	+0·4	−12·5	+ 5·5	− 7·0
6	7	4	+27·8	−0·3	−32·2	−4·7	− 4·2	+ 4·6	+ 0·4
9	7	25	+13·2	−0·3	−14·0	−1·1	− 2·5	+ 1·1	− 1·4
10	7	1	+ 7·5	−0·3	−10·7	−3·5	− 1·4	−0·2	− 1·6
11	5	58	+ 7·5	−0·3	−10·2	−3·0	+ 2·8	−1·6	+ 1·2
13	6	50	+12·0	−0·3	−15·2	−3·5	+ 0·3	−2·7	− 2·4
16	11	12	+19·4	−0·3	−21·9	−2·8	+12·0	−1·0	+11·0
17	7	58	+26·0	−0·3	−21·8	+3·9	− 0·5	−0·5	− 1·0
18	8	53	+26·0	−0·3	−20·4	+5·9	− 1·1	−0·1	− 1·2
19	8	23	+18·9	−0·3	−17·1	+1·5	− 3·2	+0·6	− 2·6
20	8	43	+14·1	−0·3	−11·7	+2·1	− 1·6	+1·0	− 0·6
21	9	4	+ 5·5	−0·3	− 5·6	−0·4	− 4·8	+1·3	− 3·5
22	9	17	+ 4·4	−0·3	− 0·6	+3·5	− 5·5	+2·1	− 3·4
23	9	47	− 0·8	−0·3	+ 2·0	+0·9	− 5·3	+2·9	− 2·4
24	10	25	− 2·3	−0·3	+ 1·7	−0·9	− 7·3	+4·3	− 3·0
25	10	59	+ 1·1	−0·3	− 0·8	0·0	− 8·6	+5·7	− 2·9
26	12	8	+ 3·6	−0·3	− 4·8	−1·5	− 9·3	+7·1	− 2·2
27	15	18	+ 8·7	−0·3	−10·2	−1·8	−12·0	+8·1	− 3·9
28	18	3	+15·2	−0·3	−16·2	−1·3	−12·2	+8·8	− 3·4
29	17	26	+18·8	−0·3	−21·9	−3·4	−10·4	+8·7	− 1·7
Oct. 5	5	56	+33·5	−0·3	−39·4	−6·2	+ 3·2	−0·1	+ 3·1
8	7	2	+12·6	−0·3	−16·0	−3·7	+ 5·9	−4·5	+ 1·4
9	6	40	+ 9·3	−0·3	−12·3	−3·3	+ 5·0	−5·3	− 0·3
12	11	37	+10·5	−0·3	−13·6	−3·4	+ 3·0	−2·6	+ 0·4
13	8	4	+12·0	−0·3	−13·6	−1·9	+ 5·0	−1·2	+ 3·8
14	7	4	+13·2	−0·3	−13·6	−0·7	+ 0·7	+0·1	+ 0·8
15	6	30	+17·9	−0·3	−14·4	+3·2	− 0·9	+1·0	+ 0·1
16	6	58	+18·2	−0·3	−15·5	+2·4	− 2·9	+2·0	− 0·9
17	8	14	+16·1	−0·3	−15·5	+0·3	− 6·3	+2·5	− 3·8
18	7	38	+17·1	−0·3	−13·3	+3·5	− 1·8	+2·6	+ 0·8
19	13	17	+10·2	−0·3	− 7·7	+2·2	− 4·4	+2·8	− 1·6
20	7	59	+ 2·4	−0·3	− 3·1	−1·0	− 6·2	+2·6	− 3·6
22	10	2	− 2·4	−0·3	+ 3·7	+1·0	− 5·4	+3·4	− 2·0
23	9	47	+ 1·1	−0·3	+ 2·1	+2·9	− 6·2	+4·2	− 2·0
24	10	39	+ 1·0	−0·3	− 2·2	−1·5	− 7·8	+5·2	− 2·6
25	11	58	+ 9·0	−0·3	− 7·7	+1·0	− 9·0	+5·9	− 3·1
27	17	43	+12·1	−0·3	−16·3	−4·5	− 8·4	+6·4	− 2·0
28	17	43	+11·8	−0·3	−18·6	−7·1	− 5·4	+5·9	+ 0·5
30	18	4	+22·8	−0·8	−26·5	−4·0	− 2·1	+3·2	+ 1·1

Errors of Hansen's Tables deduced

Approx. G.M.T. 1853.			B–O	Longitude. Corr. to B.	H–B	H–O	E.N.P.D. B–O	H–B	H–O
	d	h m	"	"	"	"	"	"	"
Nov. 8	7	57	+14.4	−0.3	−16.7	− 2.6	+6.9	−4.6	+2.3
9	6	4	+14.1	−0.3	−14.4	− 0.6	+1.6	−2.9	−1.3
10	6	4	+16.2	−0.3	−11.8	+ 4.1	+2.1	−1.0	+1.1
.11	5	1	+12.6	−0.3	− 9.3	+ 3.0	−1.9	+0.6	−1.3
12	8	44	+ 8.4	−0.3	− 7.2	+ 0.9	−2.2	+2.0	−0.2
13	8	2	+12.7	−0.3	− 7.2	+ 5.2	−4.4	+2.7	−1.7
14	11	53	+13.5	−0.3	− 8.6	+ 4.6	−3.5	+3.0	−0.5
16	7	36	+11.7	−0.8	− 9.5	+ 1.9	−6.3	+3.1	−3.2
17	7	22	+11.5	−0.3	− 7.9	+ 3.3	−6.6	+2.7	−3.9
18	7	1	+ 8.9	−0.3	− 5.4	+ 3.2	−8.4	+2.1	−6.3
19	8	12	+ 1.8	−0.3	− 2.3	− 0.8	−6.0	+1.6	−4.4
20	9	42	− 0.7	−0.3	− 0.9	− 1.9	−4.4	+1.5	−2.9
21	9	50	+ 0.7	−0.3	− 1.5	− 1.1	−7.2	+1.8	−5.4
23	11	37	+ 1.3	−0.3	− 7.9	− 6.9	−1.3	+2.6	+1.3
26	17	1	0.0	−0.3	−12.0	−12.3	−0.5	+2.0	+1.5
Dec. 2	4	31	+23.0	−0.3	−24.4	− 1.7	+9.7	−5.9	+3.8
8	6	0	+16.2	−0.3	−12.7	+ 3.2	+0.5	+1.2	+1.7
9	10	44	+11.5	−0.3	−10.6	+ 0.6	+2.5	+3.3	+5.8
12	4	44	+ 3.5	−0.3	− 4.9	− 1.7	−8.8	+5.4	−3.4
13	6	39	+ 1.1	−0.3	− 3.9	− 3.1	−9.8	+5.3	−4.5
14	5	29	+ 9.4	−0.3	− 4.4	+ 4.7	−8.0	+4.9	−3.1
15	7	22	+ 8.0	−0.3	− 6.0	+ 1.7	−7.2	+4.3	−2.9
16	6	58	+17.8	−0.3	− 7.3	+10.2	−6.2	+3.7	−2.5
17	10	13	+15.8	−0.3	− 7.8	+ 7.7	−7.9	+2.3	−5.6
18	12	26	+ 7.6	−0.3	− 7.0	+ 0.3	−2.8	+1.8	−1.0
19	10	19	+ 5.6	−0.3	− 5.8	− 0.5	−4.8	+1.4	−3.4
22	16	29	+ 9.6	−0.3	− 6.5	+ 2.8	−4.1	+1.7	−2.4
23	17	36	+12.0	−0.3	− 8.3	+ 3.4	−2.1	+1.4	−0.7
24	15	26	+ 8.5	−0.3	− 9.1	− 0.9	−7.5	+1.0	−6.5
25	16	54	+10.0	−0.3	− 7.6	+ 2.1	−2.1	−0.1	−2.2
26	18	19	+ 2.4	−0.3	− 4.7	− 2.6	+0.2	−1.0	−0.8

Approx. G.M.T. 1854.			B−0	Longitude. Corr. to B.	H−B	H−0	R.N.P.D. B−0	H−B	H−0
	d	h	m							
Jan.	1	5	8	+ 7ʺ6	−0ʺ3	−11ʺ6	− 4ʺ3	+ 4ʺ8	−5ʺ0	− 0ʺ2
	6	10	14	+ 6·9	−0·3	− 9·1	− 2·5	− 0·3	+3·5	+ 3·2
	7	6	38	+11·2	−0·3	−10·0	+ 0·9	− 2·9	+4·9	+ 2·0
	8	4	36	+13·7	−0·3	− 9·7	+ 3·7	− 6·4	+6·1	− 0·3
	13	4	38	− 1·2	−0·3	− 1·9	− 3·4	− 5·7	+5·7	0·0
	14	5	57	+ 2·6	−0·3	− 4·2	− 1·9	− 6·4	+5·0	− 1·4
	15	10	3	+ 3·4	−0·3	− 6·9	− 3·8	− 4·3	+4·3	0·0
	16	9	53	+ 8·3	−0·3	− 8·0	0·0	− 4·9	+3·7	− 1·2
	18	11	30	+ 7·7	−0·3	− 6·9	+ 0·5	− 5·9	+3·4	− 2·5
	19	11	16	− 0·4	−0·3	− 6·7	− 7·4	− 2·8	+3·4	+ 0·6
	20	12	51	+ 7·2	−0·3	− 8·1	− 1·2	− 1·6	+2·9	+ 1·3
	21	14	44	+ 4·3	−0·3	− 9·5	− 5·5	− 1·2	+1·9	+ 0·7
	22	15	13	+ 8·1	−0·3	− 9·6	− 1·8	+ 1·2	+0·3	+ 1·5
	23	17	26	− 2·8	−0·3	− 6·1	− 9·2	+ 0·4	−1·5	− 1·1
	24	18	25	− 9·8	−0·3	− 0·7	−10·8	+ 1·9	−3·1	− 1·2
	30	6	0	+ 7·7	−0·3	− 3·2	+ 4·2	+15·5	−4·7	+10·8
Feb.	2	5	27	+ 6·8	−0·3	− 4·7	+ 1·8	+ 4·0	−1·1	+ 2·9
	3	6	49	+ 7·4	−0·3	− 6·4	+ 0·7	+ 4·1	+0·6	+ 4·7
	7	5	37	+ 9·4	−0·3	− 8·4	+ 0·7	−10·9	+6·2	− 4·7
	8	7	2	+ 3·1	−0·3	− 5·5	− 2·7	− 8·7	+6·4	− 2·3
	9	5	59	+ 4·5	−0·3	− 2·4	+ 1·8	−10·7	+6·0	− 4·7
	10	6	38	− 1·5	−0·3	+ 0·1	− 1·7	− 9·9	+5·4	− 4·5
	11	7	21	− 2·3	−0·3	+ 0·5	− 2·1	− 8·4	+4·7	− 3·7
	12	7	33	− 0·9	−0·3	− 1·2	− 2·4	− 5·7	+4·3	− 1·4
	13	7	30	− 3·2	−0·3	− 3·7	− 7·2	− 6·0	+3·7	− 2·3
	14	12	50	+ 2·0	−0·3	− 6·9	− 5·2	− 1·8	+2·9	+ 1·1
	15	10	26	+ 1·3	−0·3	− 8·3	− 7·3	− 2·3	+2·5	+ 0·2
	16	15	44	+ 7·6	−0·3	− 9·8	− 2·5	+ 5·4	+1·9	+ 7·3
	17	11	35	+ 3·3	−0·3	−11·5	− 8·5	− 4·4	+1·1	− 3·3
	18	14	15	+11·7	−0·3	−13·6	− 2·2	+ 4·7	−0·6	+ 4·1
	20	16	26	+ 7·5	−0·3	−12·0	− 4·8	+ 1·6	−3·9	− 2·3
	21	17	34	+ 5·7	−0·3	− 7·0	− 1·6	+ 4·2	−5·1	− 0·9
	22	18	25	− 4·1	−0·3	− 0·6	− 5·0	+ 5·2	−5·6	− 0·4
Mar.	1	6	15	+ 1·9	−0·3	− 2·8	− 1·2	+ 4·5	−1·7	+ 2·8
	2	6	8	+ 4·3	−0·3	− 5·6	− 1·6	+ 3·9	−0·6	+ 3·3
	3	6	13	+ 7·4	−0·3	− 7·1	0·0	+ 2·5	+1·0	+ 3·5
	4	8	11	+ 7·7	−0·3	− 7·6	− 0·2	+ 5·0	+2·7	+ 7·7
	5	6	39	+13·1	−0·3	− 7·8	+ 5·0	− 1·9	+3·7	+ 1·8
	6	5	6	+ 6·4	−0·3	− 8·2	− 2·1	− 6·4	+4·7	− 1·7

Approx. G.M.T. 1854.			Longitude.				E.N.P.D.		
			B−O	Corr. to B.	H−B	H−O	B−O	H−B	H−O
	d	h	m							
Mar. 8	6	29	+ 9.6	−0.3	− 7.2	+ 2.1	− 5.9	+5.7	−0.2
9	7	16	+ 4.0	−0.3	− 4.8	− 1.1	− 6.9	+5.5	−1.4
10	6	21	− 3.2	−0.3	− 2.0	− 5.5	− 6.4	+5.0	−1.4
11	7	5	− 3.0	−0.3	+ 0.4	− 2.9	− 5.9	+4.3	−1.6
12	5	19	− 3.8	−0.3	+ 1.2	− 2.9	− 9.9	+3.9	−6.0
13	6	9	− 1.3	−0.3	+ 0.1	− 1.5	− 6.8	+3.2	−3.6
14	8	43	+ 1.3	−0.3	− 2.8	− 1.8	− 4.8	+2.2	−2.6
15	11	7	+ 7.2	−0.3	− 6.6	+ 0.3	− 1.2	+0.9	−0.3
16	9	31	+ 6.1	−0.3	− 9.7	− 3.9	+ 0.3	−0.5	−0.2
17	11	23	+10.7	−0.3	−13.0	− 2.6	+ 1.8	−2.5	−0.7
19	15	5	+ 6.0	−0.3	−16.5	−10.8	+ 7.3	−7.0	+0.3
21	17	10	+11.5	−0.3	−14.4	− 3.2	+10.1	−8.5	+1.6
30	7	25	+ 7.3	−0.3	− 3.3	+ 3.7	+ 1.5	+3.3	+4.8
31	7	33	+ 8.2	−0.3	− 6.3	+ 1.6	− 0.2	+4.2	+4.0
Apr. 1	7	16	+ 8.5	−0.3	− 7.1	+ 1.1	+ 2.1	+4.7	+6.8
3	7	17	+13.7	−0.3	− 6.5	+ 6.9	− 2.4	+5.9	+3.5
4	7	58	+11.1	−0.3	− 6.6	+ 4.2	− 4.8	+6.2	+1.4
5	8	42	+ 6.2	−0.3	− 6.7	− 0.8	− 3.7	+6.1	+2.4
6	4	44	+ 4.1	−0.3	− 6.1	− 2.3	− 7.2	+6.0	−1.2
7	6	26	+ 2.0	−0.3	− 4.7	− 3.0	− 6.1	+5.6	−0.5
8	6	49	+ 0.2	−0.3	− 2.7	− 2.8	− 6.2	+5.1	−1.1
9	7	48	− 1.8	−0.3	− 1.2	− 3.3	− 5.4	+4.8	−0.6
10	6	35	+ 0.4	−0.3	− 0.9	− 0.8	− 5.0	+4.2	−0.8
11	6	38	+ 0.6	−0.3	− 2.5	− 2.2	− 5.8	+3.3	−2.5
12	7	59	+ 0.8	−0.3	− 6.0	− 5.5	− 1.2	+1.9	+0.7
13	9	1	+ 4.3	−0.3	−10.0	− 6.0	− 1.2	+0.1	−1.1
14	10	1	+ 8.6	−0.3	−14.0	− 5.7	+ 2.0	−1.8	+0.2
15	11	31	+14.9	−0.3	−16.5	− 1.9	+ 2.9	−4.5	−1.6
17	14	33	+12.7	−0.3	−16.6	− 4.2	+ 9.9	−8.1	+1.8
18	15	57	+13.8	−0.3	−15.4	− 1.9	+ 4.5	−8.2	−3.7
19	16	25	+ 9.8	−0.3	−13.7	− 4.2	+ 2.5	−7.1	−4.6
20	18	45	+15.1	−0.3	−11.1	+ 3.7	+ 7.5	−4.9	+2.6
May 2	7	6	+ 6.2	−0.3	− 6.3	− 0.4	− 3.0	+4.7	+1.7
3	9	43	+ 3.7	−0.3	− 6.3	− 2.9	− 1.5	+4.2	+2.7
4	7	41	+ 3.8	−0.3	− 6.8	− 3.3	− 3.3	+4.0	+0.7
5	9	21	+ 6.6	−0.3	− 7.1	− 0.8	− 3.1	+3.5	+0.4
6	6	59	+ 4.7	−0.3	− 6.9	− 2.5	− 5.9	+3.6	−2.3
7	8	44	+ 9.2	−0.3	− 6.6	+ 2.3	− 6.3	+3.3	−3.0
8	10	42	+ 0.3	−0.3	− 6.8	− 6.8	− 4.2	+3.1	−1.1
9	10	41	−11.0	−0.3	− 7.7	−19.0	− 2.1	+2.9	+0.8
10	7	1	+ 3.1	−0.3	− 9.1	− 6.3	− 1.9	+2.2	+0.3
11	8	53	+ 9.1	−0.3	−12.5	− 3.7	− 4.7	+1.1	−3.6
12	9	41	+10.5	−0.3	−16.0	− 5.8	− 1.9	−0.4	−2.3

Approx. G.M.T. 1854.			B−O	Corr. to B.	Longitude. H−B	H−O	E.N.P.D. B−O	H−B	H−O
	d	h	m						
May 13	11	36	+ 16″·7	− 0″·3	− 18″·9	− 2″·5	+ 0″·7	− 2″·2	− 1″·5
15	13	39	+ 21·7	− 0·3	− 18·3	+ 3·1	− 3·2	− 3·8	− 7·0
16	14	47	+ 10·3	− 0·3	− 15·7	− 5·7	+ 1·5	− 3·4	− 1·9
18	15	50	+ 10·5	− 0·3	− 9·3	+ 0·9	+ 2·2	− 1·1	+ 1·1
30	7	43	+ 10·5	− 0·3	− 9·4	+ 0·8	+ 0·1	+ 2·0	+ 2·1
31	8	1	+ 4·5	− 0·3	− 9·2	− 5·0	+ 2·4	+ 1·0	+ 3·4
June 4	5	59	+ 4·0	− 0·3	− 10·7	− 7·0	+ 1·4	− 0·8	+ 0·6
8	9	21	+ 7·7	− 0·3	− 13·3	− 5·9	+ 4·5	− 3·0	+ 1·5
9	12	23	+ 10·6	− 0·3	− 14·7	− 4·4	+ 3·7	− 3·8	− 0·1
10	9	39	+ 12·8	− 0·3	− 16·5	− 4·0	+ 2·4	− 4·5	− 2·1
12	12	11	+ 17·5	− 0·3	− 19·0	− 1·8	+ 1·7	− 4·3	− 2·6
13	14	0	+ 16·8	− 0·3	− 16·5	0·0	+ 2·3	− 3·1	− 0·8
17	14	35	+ 6·3	− 0·3	− 4·0	+ 2·0	− 6·5	+ 3·7	− 2·8
18	15	26	+ 6·3	− 0·3	− 1·8	+ 4·2	− 5·0	+ 5·2	+ 0·2
20	15	35	− 2·5	− 0·3	+ 2·7	− 0·1	− 9·7	+ 7·4	− 2·3
28	8	27	+ 15·3	− 0·3	− 13·5	+ 1·5	− 1·6	+ 1·0	− 0·6
29	8	50	+ 10·5	− 0·3	− 13·7	− 3·5	+ 5·0	+ 0·2	+ 5·2
July 3	9	13	+ 12·2	− 0·3	− 15·6	− 3·7	+ 5·4	− 2·4	+ 3·0
6	8	18	+ 10·9	− 0·3	− 14·8	− 4·2	+ 6·9	− 6·5	+ 0·4
13	15	2	+ 9·3	− 0·3	− 11·8	− 2·8	+ 5·3	− 4·1	+ 1·2
14	14	37	+ 14·4	− 0·3	− 8·9	+ 5·2	+ 3·8	− 2·2	+ 1·6
17	16	36	+ 7·5	− 0·3	− 3·6	+ 3·6	− 3·6	+ 3·8	+ 0·2
18	14	43	+ 5·8	− 0·3	− 2·1	+ 3·4	− 9·7	+ 5·0	− 4·7
20	14	30	− 0·6	− 0·3	+ 1·6	+ 0·7	− 9·1	+ 6·2	− 2·9
21	15	28	+ 1·3	− 0·3	+ 1·9	+ 2·9	− 11·8	+ 5·9	− 5·9
22	15	38	+ 3·6	− 0·3	+ 0·4	+ 3·7	− 8·6	+ 5·4	− 3·2
28	8	37	+ 19·8	− 0·3	− 19·8	− 0·3	− 0·2	+ 2·4	+ 2·2
29	8	32	+ 16·8	− 0·3	− 20·2	− 3·7	− 4·0	+ 2·4	− 1·6
30	6	41	+ 16·8	− 0·3	− 19·8	− 3·3	+ 4·1	+ 2·1	+ 6·2
Aug. 1	7	45	+ 14·4	− 0·3	− 19·9	− 5·8	+ 3·6	+ 0·1	+ 3·7
6	8	32	+ 13·3	− 0·3	− 17·3	− 4·3	+ 4·0	− 6·9	− 2·9
7	9	53	+ 15·9	− 0·3	− 19·1	− 3·5	+ 7·5	− 7·1	+ 0·4
8	10	17	+ 22·4	− 0·3	− 21·0	+ 1·1	+ 8·0	− 6·8	+ 1·2
10	11	6	+ 19·3	− 0·3	− 20·0	− 1·0	+ 2·8	− 5·3	− 2·5
11	13	26	+ 17·8	− 0·3	− 16·7	+ 0·8	+ 2·8	− 4·2	− 1·4
12	10	48	+ 17·5	− 0·3	− 13·0	+ 4·2	− 0·5	− 2·9	− 3·4
13	14	6	+ 11·9	− 0·3	− 8·6	+ 3·0	− 0·1	− 1·1	− 1·2
14	11	11	+ 9·6	− 0·3	− 6·5	+ 2·8	− 5·2	+ 0·2	− 5·0
15	11	43	− 0·7	− 0·3	− 4·3	− 5·3	− 7·6	+ 1·7	− 5·9
16	12	4	+ 6·6	− 0·3	− 3·1	+ 3·2	− 6·4	+ 2·7	− 3·7
17	13	38	+ 3·4	− 0·3	− 3·0	+ 0·1	− 6·7	+ 3·5	− 3·2
18	16	22	+ 2·9	− 0·3	− 3·4	− 0·8	− 9·1	+ 3·7	− 5·4

Errors of Hansen's Tables deduced

Approx. G.M.T. 1854.			B–O	Corr. to B.	H–B	H–O	B–O	H–B	H–O
d	h	m			Longitude.			E.N.P.D.	
Aug. 21	15	57	+ 4″2	−0″3	− 10″0	−6″1	− 6″1	+3″3	− 2″8
28	7	21	+17·4	−0·3	−21·7	−4·6	− 2·8	+3·7	+ 0·9
29	6	32	+17·8	−0·3	−19·7	−2·2	− 0·3	+2·9	+ 2·6
30	8	3	+15·5	−0·3	−18·7	−3·5	− 0·1	+1·6	+ 1·5
31	7	43	+12·7	−0·3	−18·7	−6·3	+ 1·5	+0·2	+ 1·7
Sept. 1	5	55	+18·4	−0·3	−19·1	−1·0	+ 2·7	−0·9	+ 1·8
2	7	19	+14·0	−0·3	−19·7	−6·0	+ 3·1	−1·5	+ 1·6
3	8	10	+15·0	−0·3	−20·3	−5·6	− 2·0	−1·4	− 3·4
4	7	57	+16·0	−0·3	−21·8	−6·1	− 2·5	−1·2	− 3·7
5	8	15	+25·7	−0·3	−23·4	+2·0	− 3·6	−0·9	− 4·5
6	8	5	+24·2	−0·3	−25·2	−1·3	− 5·6	−0·6	− 6·2
7	8	23	+21·3	−0·3	−25·3	−4·3	− 4·8	−0·3	− 5·1
8	9	9	+26·3	−0·3	−23·5	+2·5	− 2·0	+0·1	− 1·9
9	8	40	+20·5	−0·3	−19·7	+0·5	− 7·1	+0·5	− 6·6
10	9	57	+17·0	−0·3	−13·9	+2·8	− 7·4	+1·1	− 6·3
11	9	29	+ 9·9	−0·3	− 8·9	+0·7	− 8·4	+1·5	− 6·9
12	9	52	+ 8·6	−0·3	− 4·8	+3·5	−11·9	+2·0	− 9·9
13	17	31	+ 4·9	−0·3	− 2·2	+2·4	+ 2·1	+2·5	+ 4·6
14	14	58	+ 1·4	−0·3	− 2·4	−1·3	− 8·5	+2·9	− 5·6
16	13	6	+15·4	−0·3	− 7·1	+8·0	−12·4	+2·7	− 9·7
17	15	24	+10·7	−0·3	−10·2	+0·2	− 8·4	+2·6	− 5·8
19	17	6	+16·9	−0·3	−18·0	−1·4	−10·6	+2·8	− 7·8
20	16	59	(+33·0)	−0·3	−23·3	(+9·4)	(−36·2)	+3·2	(−33·0)
26	6	6	+14·9	−0·3	−20·7	−6·1	− 2·1	+1·7	− 0·4
27	6	30	+14·8	−0·3	−16·4	−1·9	− 2·4	+0·5	− 1·9
28	6	36	+10·7	−0·3	−14·3	−3·9	− 3·2	−0·4	− 3·6
29	7	12	+ 9·4	−0·3	−14·2	−5·1	− 1·9	−0·8	− 2·7
30	9	9	+13·0	−0·3	−15·3	−2·6	− 0·8	−0·9	− 1·7
Oct. 1	7	5	+11·0	−0·3	−16·4	−5·7	− 2·7	−0·3	− 3·0
2	6	19	+16·0	−0·3	−17·8	−2·1	− 2·2	+0·7	− 1·5
3	6	47	+19·4	−0·3	−19·4	−0·3	− 2·5	+1·9	− 0·6
4	7	15	+20·8	−0·3	−20·5	0·0	− 7·3	+3·0	− 4·3
5	8	17	+25·1	−0·3	−21·0	+3·8	− 4·6	+4·0	− 0·6
7	12	15	+15·8	−0·3	−17·8	−2·3	− 3·4	+4·4	+ 1·0
8	11	59	+20·3	−0·3	−13·6	+6·4	− 4·6	+4·3	− 0·3
9	14	36	+ 2·6	−0·3	− 8·1	−5·8	− 1·5	+3·7	+ 2·2
10	9	36	+ 3·3	−0·3	− 4·3	−1·3	−10·1	+3·5	− 6·6
11	9	52	+ 1·3	−0·3	− 0·4	+0·6	− 7·5	+2·8	− 4·7
12	9	38	− 5·9	−0·3	+ 1·0	−5·2	− 8·0	+2·5	− 5·5
16	15	46	+ 4·7	−0·3	− 9·8	−5·4	− 6·8	+2·2	− 4·6
27	6	0	+10·3	−0·3	−16·5	−6·5	+ 5·9	−2·3	+ 3·6
28	7	6	+ 7·1	−0·3	−14·6	−7·8	+ 1·2	−2·5	− 1·3
29	6	27	+10·2	−0·3	−14·2	−4·3	+ 1·7	−2·0	− 0·3

Approx. G.M.T. 1854.		B−O	Corr. to B.	H−B	H−O	B−O	H−B	H−O
				Longitude.			E.N.P.D.	
	d h m							
Oct. 30	5 59	+12·8	−0·3	−14·4	− 1·9	− 0·6	−0·6	−1·2
31	6 36	+13·5	−0·3	−14·9	− 1·7	+ 2·0	+0·7	+2·7
Nov. 1	5 34	+14·5	−0·3	−14·5	− 0·3	− 2·8	+2·2	−0·6
2	5 13	+10·3	−0·3	−13·4	− 3·4	− 5·6	+3·5	−2·1
3	6 20	+11·8	−0·3	−12·3	− 0·8	− 0·8	+4·0	+3·2
4	10 18	+12·5	−0·3	−11·2	+ 1·0	− 6·4	+4·5	−1·9
5	7 38	+ 9·9	−0·3	−10·2	− 0·6	− 6·7	+4·2	−2·5
6	6 52	+ 8·5	−0·3	− 8·6	− 0·4	− 6·6	+3·5	−3·1
· 7	18 11	− 1·7	−0·3	− 4·3	− 6·3	− 2·3	+2·1	−0·2
8	11 11	0·0	−0·3	− 1·8	− 2·1	− 4·6	+1·4	−3·2
9	8 55	− 4·7	−0·3	+ 0·7	− 4·3	− 1·8	+0·6	−1·2
11	19 31	+ 2·9	−0·3	− 0·1	+ 2·5	− 3·3	−0·3	−3·6
12	15 20	− 0·1	−0·3	− 2·0	− 2·4	+ 0·5	−0·3	+0·2
26	4 22	+ 3·6	−0·3	−17·3	−14·0	− 2·6	−0·7	−3·3
27	9 29	+14·4	−0·3	−15·6	− 1·5	+ 3·4	+0·6	+4·0
29	4 23	+14·0	−0·3	−13·7	0·0	− 6·4	+3·1	−3·3
30	10 42	+11·7	−0·3	−10·4	+ 1·0	+ 1·1	+4·5	+5·6
Dec. 1	7 22	+ 8·5	−0·3	− 7·8	+ 0·4	− 5·8	+4·9	−0·9
2	5 56	+ 5·5	−0·3	− 6·0	− 0·8	− 5·4	+5·1	−0·3
· 3	7 1	+ 7·7	−0·3	− 5·4	+ 2·0	− 6·9	+4·7	−2·2
4	8 5	+ 8·8	−0·3	− 6·2	+ 2·3	− 7·9	+3·6	−4·3
5	7 41	+10·9	−0·3	− 6·6	+ 4·0	− 6·6	+2·3	−4·3
6	7 6	+ 0·6	−0·3	− 6·1	− 5·8	− 4·8	+0·9	−3·9
7	7 55	+ 6·2	−0·3	− 4·2	+ 1·7	− 2·3	−0·5	−2·8
8	12 54	+ 4·5	−0·3	− 1·4	+ 2·8	− 2·9	−1·6	−4·5
9	9 44	− 0·9	−0·3	0·0	− 1·2	− 1·5	−1·8	−3·3
10	10 17	− 3·9	−0·3	0·0	− 4·2	− 2·6	−1·8	−4·4
11	18 20	+ 2·4	−0·3	− 3·0	− 0·9	+ 1·7	−1·5	+0·2
12	15 0	+ 7·2	−0·3	− 5·7	+ 1·2	− 2·7	−1·4	−4·1
14	17 41	+ 4·2	−0·3	− 9·3	− 5·4	− 0·3	−1·3	−1·6
15	19 26	+ 6·6	−0·3	− 9·0	− 2·7	− 1·2	−1·2	−2·4
25	4 55	+12·8	−0·3	−12·4	+ 0·1	− 0·9	+2·3	+1·4
26	4 5	+15·4	−0·3	−11·9	+ 3·2	− 3·5	+3·6	+0·1
27	4 27	+11·9	−0·3	−11·7	− 0·1	− 3·9	+4·9	+1·0
28	3 42	+ 7·6	−0·3	−10·3	− 3·0	− 8·3	+6·2	−2·1
29	8 4	+ 3·2	−0·3	− 6·8	− 3·9	− 6·9	+7·0	+0·1
30	5 8	+ 7·8	−0·3	− 4·0	+ 3·5	−12·1	+6·9	−5·2
31	12 20	+ 0·4	−0·3	− 1·4	− 1·3	− 4·9	+6·1	+1·2

Errors of Hansen's Tables deduced

Approx. G.M.T. 1855.			Longitude.				E.N.P.D.		
			B−O	Corr. to B.	H−B	H−O	B−O	H−B	H−O
Jan.	d h m								
Jan. 3	7	43	+ 8″4	−0″3	− 4″4	+3″7	− 7″4	+2″7	−4″7
4	15	13	+ 9·0	−0·3	− 5·3	+3·4	+ 0·9	+0·9	+1·8
6	10	36	+ 0·4	−0·3	− 3·8	−3·7	− 1·3	−0·2	−1·5
9	18	58	+ 4·7	−0·3	− 5·8	−1·4	+ 1·0	−0·4	+0·6
12	18	57	+ 6·9	−0·3	−11·2	−4·6	+ 1·6	−1·9	−0·3
13	19	13	+ 1·7	−0·3	− 9·9	−8·5	+ 1·8	−2·5	−0·7
23	6	13	+ 4·9	−0·3	− 6·2	−1·6	− 3·9	+2·6	−1·3
26	5	20	+ 7·9	−0·3	− 6·4	+1·2	− 7·6	+6·0	−1·6
27	4	48	+ 6·7	−0·3	− 5·6	+0·8	−10·2	+6·3	−3·9
28	6	33	+ 3·6	−0·3	− 3·4	−0·1	− 8·6	+5·7	−2·9
29	3	35	+ 0·8	−0·3	− 1·0	−0·5	− 6·2	+4·9	−1·3
Feb. 1	17	7	− 0·1	−0·3	+ 0·5	+0·1	+ 1·5	+1·2	+2·7
3	7	37	+ 3·0	−0·3	− 2·8	−0·1	− 4·2	+1·0	−3·2
9	18	36	+ 7·9	−0·3	− 9·0	−1·4	+ 0·3	−1·1	−0·8
10	18	23	+ 9·1	−0·3	− 8·3	+0·5	+ 4·4	−2·1	+2·3
18	6	0	+ 8·0	−0·3	−12·6	−4·9	− 0·6	+1·0	+0·4
20	6	10	+12·1	−0·3	− 9·4	+2·4	+ 1·8	+1·9	+3·7
21	9	48	+ 4·2	−0·3	− 6·6	−2·7	− 1·1	+2·6	+1·5
22	6	3	+ 7·0	−0·3	− 5·9	+0·8	− 3·2	+3·2	0·0
23	6	51	+ 8·1	−0·3	− 6·5	+1·3	− 4·9	+3·5	−1·4
28	7	22	+ 2·6	−0·3	− 0·4	+1·9	− 1·9	−0·1	−2·0
Mar. 1	6	4	− 5·8	−0·3	+ 2·6	−3·5	− 3·6	−0·8	−4·4
2	10	6	− 6·5	−0·3	+ 3·8	−3·0	+ 0·6	−1·0	−0·4
3	6	41	− 2·9	−0·3	+ 2·1	−1·1	0·0	−0·8	−0·8
4	8	59	− 1·2	−0·3	− 2·1	−3·6	+ 0·4	−1·0	−0·6
5	9	35	+ 1·7	−0·3	− 6·1	−4·7	− 1·0	−0·9	−1·9
6	9	34	+ 4·6	−0·3	− 9·0	−4·7	+ 4·8	−1·5	+3·3
7	11	6	+ 3·1	−0·3	−10·6	−7·8	+ 2·0	−2·2	−0·2
8	12	16	+ 2·5	−0·3	−10·9	−8·7	+ 6·4	−2·7	+3·7
23	11	30	+ 6·6	−0·3	− 8·6	−2·3	− 4·1	+4·8	+0·7
25	7	28	+ 9·9	−0·3	−10·6	−1·0	− 4·5	+3·1	−1·4
26	8	24	+10·8	−0·3	−11·9	−1·4	− 0·1	+1·7	+1·6
27	6	13	+ 7·0	−0·3	−11·6	−4·9	− 0·5	+0·4	−0·1
28	6	59	+ 3·9	−0·3	− 9·4	−5·8	+ 2·1	−0·9	+1·2
29	4	54	+ 4·5	−0·3	− 6·2	−2·0	− 0·3	−1·7	−2·0
30	6	32	+ 2·4	−0·3	− 2·4	−0·3	+ 5·8	−2·2	+3·6
31	6	55	− 0·1	−0·3	− 0·6	−1·0	+ 2·4	+2·2	+0·2

Approx. G.M.T. 1855.			B−O	Longitude. Corr. to B.	H−B	H−O	E.N.P.D. B−O	H−B	H−O
	d	h	m							
Apr.	1	11	15	+ 0·6	− 0·3	− 1·5	− 1·2	+ 4·2	− 2·5	+ 1·7
	2	6	55	+ 6·0	− 0·3	− 3·7	+ 2·0	+ 3·9	− 2·4	+ 1·5
	4	9	47	+ 6·9	− 0·3	− 9·6	− 3·0	+ 4·5	− 3·7	+ 0·8
	6	13	15	+ 13·4	− 0·3	− 13·1	0·0	+ 8·2	− 5·8	+ 2·4
	7	15	27	+ 9·7	− 0·3	− 14·6	− 5·2	+ 5·9	− 6·4	− 0·5
	9	17	19	+ 13·3	− 0·3	− 13·7	− 0·7	+ 8·8	− 4·8	+ 4·0
	18	7	55	+ 7·3	− 0·3	− 5·5	+ 1·5	− 3·2	+ 7·6	+ 4·4
	19	7	56	+ 7·6	− 0·3	− 6·9	+ 0·4	− 4·4	+ 6·8	+ 2·4
	20	7	54	+ 14·4	− 0·3	− 7·6	+ 6·5	− 2·6	+ 5·8	+ 3·2
	21	7	29	+ 12·1	− 0·3	− 8·1	+ 3·7	− 6·3	+ 4·5	− 1·8
	22	7	14	+ 11·8	− 0·3	− 8·9	+ 2·6	− 7·3	+ 3·2	− 4·1
	23	7	48	+ 9·1	− 0·3	− 10·3	− 1·5	− 2·8	+ 1·5	− 1·3
	24	9	35	+ 6·8	− 0·3	− 11·6	− 5·1	+ 1·3	− 0·1	+ 1·2
	25	7	1	+ 9·8	− 0·3	− 12·2	− 2·7	+ 0·5	− 1·0	− 0·5
	26	10	5	+ 3·1	− 0·3	− 11·2	− 8·4	+ 4·0	− 2·1	+ 1·9
	27	7	0	+ 9·1	− 0·3	− 9·5	− 0·7	+ 4·3	− 2·3	+ 2·0
	30	10	21	+ 0·9	− 0·3	− 5·4	− 4·8	+ 3·9	− 1·8	+ 2·1
May	1	8	1	+ 4·6	− 0·3	− 6·1	− 1·8	+ 1·8	− 1·9	− 0·1
	2	8	58	+ 0·8	− 0·3	− 7·6	− 7·1	+ 2·7	− 1·9	+ 0·8
	4	12	2	+ 6·6	− 0·3	− 11·7	− 5·4	+ 4·7	− 2·7	+ 2·0
	5	14	33	+ 6·7	− 0·3	− 14·6	− 8·2	+ 5·0	− 2·7	+ 2·3
	8	16	1	+ 9·4	− 0·3	− 14·5	− 5·4	− 0·1	0·0	− 0·1
	18	8	23	+ 3·7	− 0·3	− 4·2	− 0·8	− 3·4	+ 5·5	+ 2·1
	19	8	6	+ 5·5	− 0·3	− 6·1	− 0·9	− 1·5	+ 3·6	+ 2·1
	22	8	17	+ 7·2	− 0·3	− 7·9	− 1·0	+ 2·0	− 1·4	+ 0·6
	23	7	46	+ 8·0	− 0·3	− 9·2	− 1·5	+ 2·5	− 2·5	0·0
	24	10	51	+ 8·0	− 0·3	− 10·4	− 2·7	+ 2·7	− 3·5	− 0·8
	25	8	17	+ 11·7	− 0·3	− 10·4	+ 1·0	+ 3·4	− 4·1	− 0·7
	26	7	5	+ 12·2	− 0·3	− 9·8	+ 2·1	+ 1·3	− 4·2	− 2·9
	28	11	31	+ 5·6	− 0·3	− 7·3	− 2·0	+ 6·8	− 4·1	+ 2·7
	29	8	20	+ 6·8	− 0·3	− 7·3	− 0·8	+ 3·5	− 3·9	− 0·4
June	1	11	28	+ 10·2	− 0·3	− 13·0	− 3·1	+ 1·8	− 1·9	− 0·1
	2	13	0	+ 13·1	− 0·3	− 15·6	− 2·8	+ 3·4	− 0·9	+ 2·5
	5	14	54	+ 10·2	− 0·3	− 13·2	− 3·3	− 6·6	+ 2·6	− 4·0
	7	17	38	+ 14·1	− 0·3	− 7·8	+ 6·0	− 4·9	+ 6·1	+ 1·2
	8	16	6	+ 9·1	− 0·3	− 5·1	+ 3·7	− 5·8	+ 7·7	+ 1·9
	9	16	1	+ 0·7	− 0·3	− 1·6	− 1·2	− 11·1	+ 9·0	− 2·1
	19	8	22	+ 6·9	− 0·3	− 7·8	− 1·2	+ 5·0	− 1·0	+ 4·0
	20	7	36	+ 5·1	− 0·3	− 7·6	− 2·8	+ 4·2	− 2·1	+ 2·1
	21	8	19	+ 4·5	− 0·3	− 8·4	− 4·2	+ 10·4	− 3·0	+ 7·4
	23	8	49	+ 5·9	− 0·3	− 10·1	− 4·5	+ 9·4	− 5·4	+ 4·0
	24	8	25	+ 6·6	− 0·3	− 10·1	− 3·8	+ 6·5	− 6·5	0·0
	25	9	7	+ 10·0	− 0·3	− 9·5	+ 0·2	+ 7·2	− 7·4	− 0·2

Approx. G.M.T. 1855.			Longitude.				E.N.P.D.		
			B−O	Corr. to B.	H−B	H−O	B−O	H−B	H−O
d	h	m	"	"	"	"	"	"	"
June 26	8	3	+ 9·6	−0·3	− 8·9	+0·4	+ 7·0	−7·9	−0·9
27	8	47	+10·8	−0·3	− 9·2	+1·3	+ 8·2	−7·8	+0·4
28	9	23	+14·8	−0·3	−11·3	+3·2	+ 6·7	−7·4	−0·7
29	11	41	+14·9	−0·3	−14·8	−0·2	+ 6·4	−6·1	+0·3
30	10	19	+17·6	−0·3	−17·5	−0·2	+ 7·6	−4·6	+3·0
July 3	14	22	+15·8	−0·3	−12·7	+2·8	+ 0·3	+0·3	+0·6
4	12	57	+13·6	−0·3	− 9·9	+3·4	− 5·0	+1·8	−3·2
5	13	56	+ 9·2	−0·3	− 7·1	+1·8	− 3·5	+3·8	+0·3
6	13	33	+ 8·4	−0·3	− 4·8	+3·3	− 8·1	+5·6	−2·5
18	8	30	+ 6·4	−0·3	−13·2	−7·1	+ 3·6	0·0	+3·6
19	8	20	+ 3·2	−0·3	−12·4	−9·5	+ 3·2	−0·6	+2·6
20	9	4	+ 4·0	−0·3	−12·3	−8·6	+ 3·0	−1·6	+1·4
21	8	19	+12·1	−0·3	−12·8	−1·0	+ 6·6	−2·7	+3·9
22	8	18	+10·5	−0·3	−13·4	−3·2	+ 5·5	−4·5	+1·0
25	7	23	+11·5	−0·3	−14·6	−3·4	+ 9·1	−8·4	+0·7
26	10	6	+13·8	−0·3	−15·7	−2·2	+10·4	−8·9	+1·5
27	9	36	+15·2	−0·3	−17·2	−2·3	+ 7·0	−8·3	−1·3
28	10	31	+18·6	−0·3	−19·2	−0·9	+ 5·0	−7·2	−2·2
29	11	23	+21·0	−0·3	−20·0	+0·7	+ 4·3	−5·8	−1·5
31	10	49	+18·4	−0·3	−15·9	+2·2	− 1·1	−3·2	−4·3
Aug. 1	12	27	+15·4	−0·3	−11·3	+3·8	+ 1·2	−1·4	−0·2
2	11	12	+11·9	−0·3	− 7·8	+3·8	− 4·0	0·0	−4·0
3	12	48	+14·1	−0·3	− 4·9	+8·9	− 4·1	+2·2	−1·9
5	13	19	+· 4·9	−0·3	− 2·1	+2·5	− 7·1	+4·6	−2·5
7	14	38	+ 3·9	−0·3	− 1·7	+1·9	− 4·0	+4·5	+0·5
9	15	33	+ 4·1	−0·3	− 5·2	−1·4	− 4·4	+2·8	−1·6
16	7	57	+19·9	−0·3	−19·9	−0·3	− 0·9	+1·2	+0·3
17	7	48	+18·0	−0·3	−18·5	−0·8	− 0·8	+1·2	+0·4
20	7	15	+15·2	−0·3	−17·9	−3·0	+ 2·7	−1·8	+0·9
21	7	2	+17·8	−0·3	−19·4	−1·9	+ 1·7	−3·1	−1·4
22	8	34	+22·5	−0·3	−20·8	+1·4	+ 3·3	−4·1	−0·8
23	9	55	+19·9	−0·3	−21·2	−1·6	+ 3·6	−4·3	−0·7
24	11	21	+15·1	−0·3	−20·6	−5·8	+ 3·4	−3·5	−0·1
25	8	25	+16·9	−0·3	−20·5	−3·9	+ 2·0	−3·0	−1·0
26	9	1	+17·8	−0·3	−20·9	−3·4	+ 0·8	−2·1	−1·3
27	8	46	+19·4	−0·3	−21·1	−2·0	− 0·4	−1·0	−1·4
28	9	5	+24·2	−0·3	−20·3	+3·6	− 6·4	−0·1	−6·5
29	8	59	+20·3	−0·3	−17·3	+2·7	− 8·4	+0·8	−7·6
30	10	19	+17·6	−0·3	−12·6	+4·7	− 8·6	+1·6	−7·0
31	9	38	+10·4	−0·3	− 8·2	+1·9	− 9·2	+2·7	−6·5

Approx. G.M.T. 1855.			Longitude.			E.N.P.D.		
		B−0	Corr. to B.	H−B	H−0	B−0	H−B	H−0
d h m		"	"	"	"	"	"	"
Sept. 1	10 10	+ 7·9	−0·3	− 5·1	+ 2·5	−11·4	+3·5	−7·9
2	10 32	+ 5·8	−0·3	− 3·8	+ 1·7	−11·2	+3·7	−7·5
3	11 45	+11·4	−0·3	− 3·6	+ 7·5	− 9·6	+3·7	−5·9
4	18 8	+ 9·8	−0·3	− 4·8	+ 4·7	− 5·2	+2·6	−2·6
5	12 20	+ 6·6	−0·3	− 5·3	+ 1·0	−10·0	+1·9	−8·1
6	16 5	+ 4·7	−0·3	− 6·1	− 1·7	− 5·4	+0·8	−4·6
7	16 54	+ 4·2	−0·3	− 7·1	− 3·2	− 4·0	0·0	−4·0
19	7 16	+14·5	−0·3	−18·5	− 4·3	+ 1·1	−0·1	+1·0
20	6 15	+13·0	−0·3	−19·3	− 6·6	− 1·3	0·0	−1·3
21	6 20	+18·5	−0·3	−18·7	− 0·5	− 0·7	+0·6	−0·1
22	6 36	+13·4	−0·3	−17·1	− 4·0	− 0·9	+1·7	+0·8
23	8 3	+15·2	−0·3	−16·0	− 1·1	+ 0·7	+2·8	+3·5
24	7 10	+19·9	−0·3	−16·3	+ 3·3	− 4·2	+3·6	−0·6
25	7 25	+18·5	−0·3	−17·5	+ 0·7	− 7·6	+4·8	−2·8
26	7 53	+15·9	−0·3	−18·0	− 2·4	−11·3	+5·7	−5·6
28	8 12	+15·3	−0·3	−13·1	+ 1·9	−11·2	+6·1	−5·1
29	9 25	+15·0	−0·3	− 9·6	+ 5·1	−10·6	+5·9	−4·7
30	10 16	+10·2	−0·3	− 7·1	+ 2·8	− 7·0	+5·0	−2·0
Oct. 1	9 37	+11·4	−0·3	− 6·0	+ 5·1	− 6·4	+4·2	−2·2
2	9 37	+ 8·8	−0·3	− 5·8	+ 2·7	− 8·4	+3·1	−5·3
3	23 34	+17·7	−0·3	− 6·5	+10·9	+ 3·5	+1·2	+4·7
4	13 30	+ 8·5	−0·3	− 6·8	+ 1·4	− 9·3	+0·4	−8·9
6	18 34	+ 8·0	−0·3	− 8·5	− 0·8	− 2·1	−0·8	−2·9
7	15 53	+10·4	−0·3	− 9·8	+ 0·3	− 6·5	−0·8	−7·3
16	6 3	+ 7·7	−0·3	−13·1	− 5·7	− 0·1	+0·7	+0·6
18	5 5	+ 6·9	−0·3	−12·4	− 5·8	− 1·9	−0·1	−2·0
19	5 0	+ 8·3	−0·3	−12·3	− 4·3	+ 0·9	+0·2	+1·1
20	6 41	+10·1	−0·3	−11·6	− 1·8	− 0·1	+1·2	+1·1
22	9 14	+ 9·6	−0·3	− 9·9	− 0·6	+ 0·2	+3·8	+4·0
23	14 25	+ 3·9	−0·3	−10·2	− 6·6	− 5·0	+5·4	+0·4
24	5 57	+10·0	−0·3	−10·6	− 0·9	− 7·9	+6·3	−1·6
25	8 58	+13·5	−0·3	−11·2	+ 2·0	− 7·5	+7·0	−0·5
27	7 10	+ 8·4	−0·3	−10·5	− 2·4	−10·6	+6·3	−4·3
28	10 41	+10·0	−0·3	− 9·1	+ 0·6	− 7·9	+5·2	−2·7
31	17 40	+ 3·2	−0·3	− 5·3	− 2·4	− 0·8	+0·8	0·0
Nov. 3	17 8	+ 1·2	−0·3	− 6·7	− 5·8	− 1·7	−1·3	−3·0
5	17 55	+ 6·4	−0·3	− 8·2	− 2·1	− 1·1	−1·5	−2·6
15	6 36	+ 6·1	−0·3	−11·1	− 5·3	− 1·3	−0·3	−1·6
20	8 47	+ 6·6	−0·3	− 9·1	− 2·8	− 6·3	+4·4	−1·9
22	6 2	+ 8·1	−0·3	− 6·7	+ 1·1	− 7·5	+6·0	−1·5
23	8 35	+ 3·6	−0·3	− 6·1	− 2·8	− 7·8	+6·1	−1·7
24	6 53	+ 6·5	−0·3	− 6·7	− 0·5	− 4·9	+5·4	+0·5
25	6 45	+11·0	−0·3	− 7·5	+ 3·2	− 4·4	+4·3	−0·1

Errors of Hansen's Tables deduced

Approx. G.M.T. 1855.			Longitude.				E.N.P.D.		
			B−O	Corr. to B.	H−B	H−O	B−O	H−B	H−O
d	h	m							
Nov. 26	10	27	+ 8˝2	−0˝3	− 7˝6	+0˝3	− 4˝8	+2˝7	− 2˝1
27	11	43	+ 8·0	−0·3	− 6·3	+1·4	− 1·6	+1·2	− 0·4
28	9	42	+ 2·7	−0·3	− 4·4	−2·0	+ 0·1	+0·1	+ 0·2
29	14	59	+ 5·0	−0·3	− 3·3	+1·4	− 0·4	−1·1	− 1·5
30	11	35	+ 1·5	−0·3	− 3·6	−2·4	− 0·9	−1·8	− 2·7
Dec. 2	15	53	+ 5·0	−0·2	− 5·4	−0·7	+ 3·1	−2·7	+ 0·4
4	20	3	+ 5·4	−0·3	− 5·3	−0·2	+ 1·8	−3·0	− 1·2
5	18	14	+ 3·5	−0·3	− 5·9	−2·7	+ 5·5	−2·8	+ 2·7
6	18	47	+ 7·3	−0·3	− 8·5	−1·5	+ 3·1	−2·6	+ 0·5
12	4	57	+25·1	−0·3	−21·4	+3·4	+13·5	−0·2	+13·3
13	5	39	+13·5	−0·3	−17·5	−4·3	+ 3·4	+0·2	+ 3·6
15	7	48	+10·6	−0·3	−12·0	−1·7	+ 5·8	+1·0	+ 6·8
17	9	37	+10·8	−0·3	−12·4	−1·9	+ 1·3	+3·9	+ 5·2
18	3	53	+ 9·9	−0·3	−12·1	−2·5	−10·7	+5·2	− 5·5
19	3	26	+ 6·4	−0·3	−10·5	−4·4	−10·7	+6·4	− 4·3
20	4	31	+ 8·4	−0·3	− 7·8	+0·3	−13·2	+7·0	− 6·2
21	4	47	+ 3·3	−0·3	− 5·6	−2·6	−11·0	+6·9	− 4·1
22	4	43	+ 2·4	−0·3	− 4·6	−2·5	− 7·8	+6·1	− 1·7
23	10	29	− 0·1	−0·3	− 5·0	−5·4	− 3·9	+4·5	+ 0·6
24	5	35	+ 3·0	−0·3	− 5·7	−3·0	− 2·4	+3·6	+ 1·2
26	7	55	+ 4·9	−0·3	− 4·5	+0·1	+ 0·6	+1·0	+ 1·6
27	9	49	+ 3·4	−0·3	− 2·9	+0·2	− 1·6	−0·1	− 1·7
28	10	53	+ 0·3	−0·3	− 2·1	−2·1	0·0	−0·5	− 0·5
29	14	49	− 0·4	−0·3	− 3·1	−3·8	+ 3·6	−1·1	+ 2·5
30	12	45	+ 1·9	−0·3	− 4·4	−2·8	+ 8·2	−1·5	+ 6·7

Approx. G.M.T. 1856.			Longitude.				R.N.P.D.		
			B−0	Corr. to B.	H−B	H−0	B−0	H−B	H−0
d	h	m							
Jan. 10	4	47	+22˝4	−0˝3	−23˝8	−1˝7	+ 5˝0	+1˝2	+6˝2
11	6	46	+14·9	−0·3	−19·5	−4·9	+ 1·7	+2·4	+4·1
12	5	52	+12·8	−0·3	−15·2	−2·7	− 0·4	+3·0	+2·6
13	4	26	+13·0	−0·3	−12·1	+0·6	− 7·1	+4·2	−2·9
14	4	19	+ 7·6	−0·3	−10·8	−3·5	−11·1	+5·6	−5·5
15	4	22	+ 9·1	−0·3	−10·9	−2·1	− 8·2	+6·8	−1·4
18	6	14	+ 1·2	−0·3	− 5·9	−5·0	− 9·7	+6·7	−3·0
19	4	34	0·0	−0·3	− 3·3	−3·6	− 3·8	+5·5	+1·7
20	5	52	+ 0·7	−0·3	− 1·7	−1·3	− 2·6	+4·1	+1·5
23	7	21	+ 2·0	−0·3	− 3·1	−1·4	+ 0·7	+1·7	+2·4
24	9	27	+ 0·7	−0·3	− 3·4	−3·0	− 1·9	+1·0	−0·9
25	9	4	+ 0·1	−0·3	− 2·8	−3·0	+ 1·3	+0·5	+1·8
26	15	19	+ 0·2	−0·3	− 2·4	−2·5	+ 2·8	0·0	+2·8
27	11	50	− 4·0	−0·3	− 2·7	−7·0	+ 3·6	−0·3	+3·3
28	15	16	+ 1·8	−0·3	− 4·0	−2·5	+ 7·2	−1·3	+5·9
29	14	57	+ 4·5	−0·3	− 5·2	−1·0	− 0·2	−2·4	−2·6
30	15	58	+ 4·1	−0·3	− 6·3	−2·5	+ 3·0	−3·2	−0·2
31	16	31	+ 6·4	−0·3	− 6·6	−0·5	+ 2·3	−4·6	−1·7
Feb. 8	5	16	+21·3	−0·3	−25·5	−4·5	− 1·8	+3·5	+1·7
9	5	39	+16·8	−0·3	−21·6	−5·1	− 7·0	+4·6	−2·4
11	5	53	+10·9	−0·3	−11·5	−0·9	− 4·9	+5·9	+1·0
12	9	4	+ 5·9	−0·3	− 9·3	−3·7	− 6·4	+6·5	+0·1
13	10	1	+ 3·5	−0·3	− 9·3	−6·1	− 5·3	+6·2	+0·9
14	3	38	+ 1·8	−0·3	− 9·2	−7·7	− 6·4	+5·6	−0·8
15	3	55	+ 4·9	−0·3	− 7·9	−3·3	− 5·8	+4·3	−1·5
16	4	33	+ 1·1	−0·3	− 5·1	−4·3	− 5·3	+2·6	−2·7
20	9	42	+ 4·9	−0·3	+ 0·1	+4·7	− 2·9	−1·2	−4·1
22	18	2	+ 5·8	−0·3	− 4·6	+0·9	+ 4·4	−1·1	+3·3
24	10	41	− 0·3	−0·3	− 5·2	−5·8	+ 1·7	−1·2	+0·5
26	14	51	0·0	−0·3	− 4·7	−5·0	+ 2·9	−2·6	+0·3
Mar. 8	7	26	+19·6	−0·3	−23·1	−3·8	− 4·3	+6·0	+1·7
11	6	55	+ 9·1	−0·3	−11·4	−2·6	− 5·4	+6·4	+1·0
12	6	56	+ 4·1	−0·3	− 9·5	−5·7	− 6·0	+5·4	−0·6
13	7	0	+ 4·2	−0·3	− 9·1	−5·2	− 9·2	+4·0	−5·2
14	6	38	+ 8·7	−0·3	− 9·6	−1·2	− 1·4	+2·1	+0·7
19	7	54	+ 1·2	−0·3	− 1·3	−0·4	+ 0·2	−4·2	−4·0
21	9	48	+ 3·8	−0·3	− 3·3	+0·2	+ 2·6	−3·8	−1·2
22	11	25	+ 5·0	−0·3	− 5·8	−1·1	+ 4·2	−3·6	+0·6

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Errors of Hansen's Tables deduced

Approx. G.M.T. 1856.			Longitude.				E.N.P.D.		
			B−O	Corr. to B.	H−B	H−O	B−O	H−B	H−O
d	h	m	"	"	"	"	"	"	"
Mar. 26	13	37	+ 4·1	− 0·3	− 8·8	− 5·0	+ 2·2	− 4·2	− 2·0
27	15	35	+ 2·1	− 0·3	− 7·8	− 6·0	− 0·9	− 4·3	− 5·2
28	16	48	− 1·1	− 0·3	− 6·0	− 7·4	+ 4·5	− 4·2	+ 0·3
29	17	26	− 4·6	− 0·3	− 3·3	− 8·2	+ 1·3	− 3·8	− 2·5
30	17	30	− 7·8	− 0·3	+ 0·5	− 7·6	+ 1·7	− 3·1	− 1·4
31	17	17	− 5·0	− 0·3	+ 4·3	− 1·0	− 5·5	− 2·1	− 7·6
Apr. 6	7	42	+ 8·4	− 0·3	− 12·3	− 4·2	− 12·1	+ 8·0	− 4·1
7	7	7	+ 9·9	− 0·3	− 13·0	− 3·4	− 10·5	+ 8·4	− 2·1
9	6	31	+ 6·6	− 0·3	− 8·9	− 2·6	− 6·3	+ 6·0	− 0·3
10	7	20	+ 7·5	− 0·3	− 7·7	− 0·5	− 2·0	+ 4·2	+ 2·2
12	9	24	+ 8·3	− 0·3	− 10·1	− 2·1	− 0·5	0·0	− 0·5
13	6	48	+ 7·7	− 0·3	− 11·9	− 4·5	− 0·5	− 1·8	− 2·3
15	6	41	+ 6·0	− 0·3	− 12·0	− 6·3	+ 4·0	− 4·6	− 0·6
16	6	40	+ 4·3	− 0·3	− 9·6	− 5·6	+ 7·4	− 5·1	+ 2·3
17	7	10	+ 3·4	− 0·3	− 6·8	− 3·7	+ 5·7	− 5·3	+ 0·4
18	9	56	− 1·0	− 0·3	− 4·4	− 5·7	+ 3·4	− 4·8	− 1·4
19	7	46	+ 1·7	− 0·3	− 4·0	− 2·6	+ 1·3	− 4·3	− 3·0
20	9	55	− 2·9	− 0·3	− 5·3	− 8·5	+ 3·7	− 3·8	− 0·1
21	10	7	+ 4·2	− 0·3	− 7·6	− 3·7	+ 2·2	− 3·5	− 1·3
22	13	11	+ 7·4	− 0·3	− 10·2	− 3·1	+ 3·9	− 3·1	+ 0·8
27	17	54	+ 0·5	− 0·3	− 9·0	− 8·8	+ 0·4	− 1·0	− 0·6
28	16	13	+ 0·3	− 0·3	− 5·2	− 5·2	− 3·7	+ 0·1	− 3·6
May 10	7	41	+ 5·3	− 0·3	− 7·4	− 2·4	− 2·6	+ 1·4	− 1·2
11	7	42	+ 10·4	− 0·3	− 10·1	0·0	+ 3·1	− 0·6	+ 2·5
13	8	18	+ 11·7	− 0·3	− 15·0	− 3·6	+ 4·7	− 4·2	+ 0·5
14	6	41	+ 11·6	− 0·3	− 14·6	− 3·3	+ 2·2	− 4·9	− 2·7
16	10	32	+ 6·3	− 0·3	− 7·6	− 1·6	+ 7·3	− 5·3	+ 2·0
17	11	2	+ 3·6	− 0·3	− 4·1	− 0·8	+ 3·2	− 4·9	− 1·7
18	7	46	+ 0·7	− 0·3	− 3·2	− 2·8	+ 0·8	− 4·2	− 3·4
19	9	22	+ 4·1	− 0·3	− 3·5	+ 0·3	+ 2·3	− 3·2	− 0·9
20	10	55	+ 1·3	− 0·3	− 5·8	− 4·8	+ 2·5	− 2·3	+ 0·2
22	12	56	+ 3·1	− 0·3	− 10·3	− 7·5	− 3·6	− 0·4	− 4·0
23	13	28	+ 8·6	− 0·3	− 12·7	− 4·4	− 3·0	+ 0·3	− 2·7
25	16	13	+ 13·1	− 0·3	− 15·5	− 2·7	− 3·1	+ 2·5	− 0·6
26	17	18	+ 15·1	− 0·3	− 14·3	+ 0·5	− 5·0	+ 4·0	− 1·0
28	15	30	+ 6·6	− 0·3	− 4·0	+ 2·3	− 10·6	+ 7·0	− 3·6
June 4	8	59	+ 3·3	− 0·3	− 2·9	+ 0·1	− 7·9	+ 9·2	+ 1·3
5	8	58	+ 3·6	− 0·3	− 6·3	− 3·0	− 5·7	+ 7·5	+ 1·8

Approx. G.M.T. 1856.			B—O	Longitude. Corr. to B.	H—B	H—O	E.N.P.D. B—O	H—B	H—O
	d	h m							
June 6	8	36	+ 6ʺ1	−0ʺ3	− 8ʺ0	−2ʺ2	− 4ʺ6	+ 5ʺ5	+0ʺ9
7	9	53	+ 7·1	−0·3	− 9·0	−2·2	− 1·1	+ 3·2	+2·1
8	8	43	+ 9·7	−0·3	− 9·6	−0·2	+ 0·6	+ 1·2	+1·8
10	7	12	+ 9·0	−0·3	−10·9	−2·2	+ 1·9	− 2·5	−0·6
11	6	15	+10·2	−0·3	−11·3	−1·4	+ 1·7	− 4·0	−2·3
14	7	15	+ 1·0	−0·3	− 5·8	−5·1	+ 5·8	− 6·8	−1·0
15	8	7	+ 0·6	−0·3	− 4·4	−4·1	+ 4·6	− 6·6	−2·0
16	8	24	+ 6·5	−0·3	− 4·6	+1·6	+ 3·0	− 6·2	−3·2
17	12	20	+12·3	−0·3	− 6·4	+5·6	+ 9·2	− 5·0	+4·2
19	14	11	+ 7·4	−0·3	−10·3	−3·2	− 1·7	− 2·5	−4·2
20	15	47	+11·6	−0·3	−12·0	−0·7	+ 0·1	− 1·1	−1·0
22	13	3	+13·9	−0·3	−15·0	−1·4	− 4·4	+ 1·6	−2·8
23	15	42	+19·6	−0·3	−15·2	+4·1	− 2·8	+ 3·4	+0·6
25	14	54	+ 8·3	−0·3	− 9·7	−1·7	− 9·2	+ 7·2	−2·0
26	15	34	+ 2·9	−0·3	− 5·1	−2·5	−10·0	+ 9·0	−1·0
27	13	39	− 5·9	−0·3	− 1·2	−7·4	− 9·6	+ 9·8	+0·2
28	14	31	− 1·0	−0·3	+ 1·4	+0·1	−15·7	+10·3	−5·4
29	15	6	− 7·5	−0·3	+ 1·6	−6·2	−12·9	+10·2	−2·7
July 3	9	1	+13·9	−0·3	−12·1	+1·5	− 8·0	+ 6·3	−1·7
5	8	29	+13·6	−0·3	−15·4	−2·1	− 0·5	+ 3·6	+3·1
8	10	14	+ 3·9	−0·3	− 8·9	−5·3	+ 2·9	− 0·6	+2·3
10	9	20	+ 3·8	−0·3	− 6·7	−3·2	+ 6·8	− 3·4	+3·4
12	10	32	+ 2·5	−0·3	− 6·0	−3·8	+ 6·8	− 6·2	+0·6
14	8	10	+ 6·6	−0·3	− 8·4	−2·1	+ 7·5	− 7·6	−0·1
15	8	48	+10·3	−0·3	−11·0	−1·0	+ 8·2	− 7·6	+0·6
16	9	19	+15·6	−0·3	−13·3	+2·0	+ 6·6	− 6·9	−0·3
17	11	21	+10·8	−0·3	−15·4	−4·9	+ 5·5	− 6·0	−0·5
18	10	17	+13·8	−0·3	−16·4	−2·9	+ 2·9	− 4·9	−2·0
22	11	12	+14·0	−0·3	−11·2	+2·5	− 5·3	+ 2·5	−2·8
24	12	11	+ 7·9	−0·3	− 6·8	+0·8	−10·3	+ 6·4	−3·9
25	12	48	+ 5·6	−0·3	− 6·1	−0·8	−12·4	+ 7·0	−5·4
26	12	41	+10·6	−0·3	− 6·3	+4·0	−12·6	+ 7·1	−5·5
28	15	57	+ 7·7	−0·3	− 8·7	−1·3	− 6·3	+ 5·3	−1·0
29	14	55	+11·3	−0·3	−10·9	+0·1	− 4·8	+ 4·0	−0·8
Aug. 3	8	5	+21·2	−0·3	−21·0	−0·1	− 1·3	+ 1·3	0·0
4	7	59	+15·7	−0·3	−16·9	−1·5	+ 1·2	+ 1·2	+2·4
5	7	56	+ 8·4	−0·3	−12·5	−4·4	− 1·8	+ 1·0	−0·8
6	8	2	+ 8·1	−0·3	− 8·6	−0·8	− 1·1	+ 0·6	−0·5

Errors of Hansen's Tables deduced

Approx. G.M.T. 1856			B−O	Longitude. Corr. to B.	H−B	H−O	R.N.P.D. B−O	H−B	H−O
	d	h m							
Aug.	7	8 32	− 1″·1	−0″·3	− 6″·6	− 8″·0	− 4″·3	−0″·3	−4″·6
	9	7 11	+ 1·1	−0·3	− 7·8	− 7·0	+ 2·7	−2·5	+0·2
	10	7 42	− 0·4	−0·3	− 9·8	−10·5	+ 3·5	−3·8	−0·3
	12	7 56	+12·2	−0·3	−14·2	− 2·3	+ 6·0	−5·2	+0·8
	13	7 48	+13·1	−0·3	−15·7	− 2·9	+ 5·1	−5·3	−0·2
	14	8 4	+12·5	−0·3	−17·0	− 4·8	+ 0·7	−5·0	−4·3
	15	8 56	+19·3	−0·3	−18·5	+ 0·5	+ 3·1	−4·2	−1·1
	16	9 25	+19·2	−0·3	−19·5	− 0·6	+ 3·7	−3·1	+0·6
	21	11 20	+13·1	−0·3	− 6·3	+ 6·5	−11·6	+5·1	−6·5
	22	11 13	+ 9·3	−0·3	− 6·9	+ 2·1	−13·5	+5·6	−7·9
	23	14 55	+11·7	−0·3	− 8·7	+ 2·7	−10·0	+5·0	−5·0
	25	15 3	+ 9·9	−0·3	− 9·1	+ 0·5	− 5·4	+2·5	−2·9
Sept.	4	7 0	+ 5·7	−0·3	−12·1	− 6·7	− 1·5	+0·9	−0·6
	5	6 54	+ 9·0	−0·3	−10·4	− 1·7	− 0·4	+0·9	+0·5
	10	8 40	+12·6	−0·3	−14·6	− 2·3	+ 2·2	−1·3	+0·9
	11	7 18	+ 9·9	−0·3	−14·0	− 4·4	− 1·6	−1·1	−2·7
	12	11 4	+ 9·9	−0·3	−13·8	− 4·2	+ 2·3	−0·5	+1·8
	13	7 44	+14·3	−0·3	−14·5	− 0·5	− 3·6	+0·4	−3·2
	14	8 1	+20·4	−0·3	−15·1	+ 5·0	− 6·4	+1·6	−4·8
	15	8 22	+·15·1	−0·3	−15·1	− 0·3	− 5·0	+3·3	−1·7
	16	7 54	+10·4	−0·3	−13·4	− 3·3	− 9·1	+4·5	−4·6
	17	10 38	+14·2	−0·3	−11·4	+ 2·5	− 8·4	+5·6	−2·8
	18	12 14	+10·0	−0·3	−10·6	− 0·9	−14·4	+6·4	−8·0
	19	9 37	+15·6	−0·3	−11·2	+ 4·1	−12·2	+6·0	−6·2
	20	10 53	+12·3	−0·3	−11·9	+ 0·1	−14·4	+5·1	−9·3
	21	14 14	+14·8	−0·3	−11·8	+ 2·7	−10·4	+3·6	−6·8
	22	12 30	+17·5	−0·3	−10·5	+ 6·7	− 8·7	+2·1	−6·6
	23	14 13	+ 8·8	−0·3	− 8·7	− 0·2	− 5 5	+0·7	−4·8
	24	15 56	+ 6·4	−0·3	− 7·6	− 1·5	− 2·4	−0·3	−2·7
	25	17 24	+ 6·9	−0·3	− 8·2	− 1·6	− 1·0	−0·5	−1·5
Oct.	10	6 18	+ 4·9	−0·3	− 9·8	− 5·2	− 2·6	+1·8	−0·8
	12	10 41	+ 1·9	−0·3	− 7·8	− 6·2	− 3·6	+3·9	+0·3
	13	7 39	+ 7·3	−0·3	− 8·7	− 1·7	− 5·9	+5·3	−0·6
	14	7 19	+ 8·5	−0·3	−10·3	− 2·1	− 9·9	+6·3	−3 6
	16	11 50	+13·4	−0·3	−13·2	− 0·1	−11·9	+6·4	−5·5
	18	9 18	+12 9	−0·3	−13·7	− 1·1	− 4·9	+4·2	−0·7
	20	10 50	+ 9·9	−0·3	−12·5	− 2·9	− 1·9	+1·3	−0·6
	21	12 28	+12·0	−0·3	−11·4	+ 0·3	− 1·6	−0·2	−1·8
	25	18 0	+ 9·0	−0·3	− 7·7	+ 1·0	0·0	−1·9	−1·9

Approx. G.M.T. 1856.			B−O	Longitude. Corr. to B.	H−B	H−O	B−O	R.N.P.D. H−B	H−O
	d	h m	$+8.9$	-0.3	-11.5	-2.9	-1.0	$+0.7$	-0.3
Nov.	4	6 14	$+8.9$	-0.3	-11.5	-2.9	-1.0	$+0.7$	-0.3
	5	4 54	$+6.4$	-0.3	-11.0	-4.9	-3.1	$+0.4$	-2.7
	6	5 40	$+7.4$	-0.3	-11.4	-4.3	-3.2	$+0.6$	-2.6
	8	9 27	$+5.0$	-0.3	-9.4	-4.7	-1.7	$+2.5$	$+0.8$
	9	9 45	$+4.8$	-0.3	-7.0	-2.5	-3.7	$+3.8$	$+0.1$
	10	9 10	-2.2	-0.3	-5.7	-8.2	-7.0	$+4.9$	-2.1
	11	7 20	$+3.6$	-0.3	-6.6	-3.3	-9.1	$+5.9$	-3.2
	12	9 29	$+9.8$	-0.3	-9.0	$+0.5$	-7.8	$+6.4$	-1.4
	13	20 21	$+13.2$	-0.3	-11.2	$+1.7$	-5.3	$+5.5$	$+0.2$
	14	7 26	$+10.2$	-0.3	-11.6	-1.7	-7.5	$+5.2$	-2.3
	15	12 1	$+12.2$	-0.3	-11.3	$+0.6$	-8.1	$+3.7$	-4.4
	16	9 3	$+10.5$	-0.3	-10.7	-0.5	-9.0	$+2.4$	-6.6
	17	10 8	$+10.5$	-0.3	-10.5	-0.3	-5.1	$+0.8$	-4.3
Dec.	2	4 48	$+13.1$	-0.3	-13.4	-0.6	$+2.4$	-1.4	$+1.0$
	3	7 26	$+10.1$	-0.3	-11.4	-1.6	$+5.9$	-1.8	$+4.1$
	7	5 20	$+12.5$	-0.3	-12.7	-0.5	-1.2	$+3.1$	$+1.9$
	8	4 43	$+9.5$	-0.3	-11.3	-2.1	-3.6	$+4.4$	$+0.8$
	9	10 40	$+6.1$	-0.3	-10.0	-4.2	-7.5	$+5.6$	-1.9
	10	7 15	$+8.1$	-0.3	-9.9	-2.1	-9.4	$+5.9$	-3.5
	11	15 37	$+7.4$	-0.3	-10.3	-3.2	-5.1	$+5.8$	$+0.7$
	12	7 15	$+8.3$	-0.3	-10.1	-2.1	-6.2	$+5.2$	-1.0
	13	8 16	$+5.1$	-0.3	-9.9	-5.1	-6.0	$+4.4$	-1.6
	14	10 53	$+5.7$	-0.3	-9.4	-4.0	-4.6	$+3.5$	-1.1
	15	11 11	$+8.3$	-0.3	-9.0	-1.0	-4.2	$+2.3$	-1.9
	16	10 24	$+5.4$	-0.3	-8.5	-3.4	-10.3	$+1.1$	-9.2
	17	17 47	$+5.1$	-0.3	-8.2	-3.4	$+2.2$	-0.6	$+1.6$
	18	18 31	$+7.1$	-0.3	-7.9	-1.1	$+3.1$	-2.0	$+1.1$
	30	4 51	$+12.5$	-0.3	-19.4	-7.2	$+3.5$	-2.3	$+1.2$

Errors of Hansen's Tables deduced

Approx. G.M.T. 1857.		Longitude.				R.N.P.D.		
		B–O	Corr. to B.	H–B	H–O	B–O	H–B	H–O
d h m		"	"	"	"	"	"	"
Jan. 2 3 52		+ 9·3	–0·3	–12·3	–3·3	–1·4	–0·3	–1·7
3 4 57		+10·5	–0·3	–12·5	–2·3	–5·7	+1·5	–4·2
5 3 58		+ 6·4	–0·3	–14·3	–8·2	–4·6	+4·1	–0·5
9 18 32		+ 9·9	–0·3	–10·3	–0·7	–4·7	+4·0	–0·7
10 6 4		+ 5·7	–0·3	–10·0	–4·6	–5·5	+3·7	–1·8
11 11 40		+ 8·7	–0·3	–10·1	–1·7	–4·3	+3·2	–1·1
12 8 47		+ 8·1	–0·3	–10·6	–2·8	–5·8	+2·8	–3·0
13 11 25		+ 7·5	–0·3	–10·4	–3·2	–1·8	+2·1	+0·3
14 10 23		+ 4·5	–0·3	– 9·2	–5·0	–4·7	+1·3	–3·4
15 11 59		+ 1·1	–0·3	– 7·8	–7·0	–0·2	+0·3	+0·1
16 13 49		+ 1·9	–0·3	– 6·7	–5·1	–0·1	–0·6	–0·7
19 18 3		+ 4·3	–0·3	– 5·7	–1·7	+6·2	–2·7	+3·5
29 5 24		+15·4	–0·3	–21·8	–6·7	–3·9	+1·4	–2·5
30 5 47		+11·9	–0·3	–17·6	–6·0	–3·3	+2·8	–0·5
31 5 23		+10·6	–0·3	–14·5	–4·2	–6·2	+4·0	–2·2
Feb. 1 7 15		+ 7·9	–0·3	–13·6	–6·0	–4·0	+4·9	+0·9
2 7 23		+ 9·6	–0·3	–14·9	–5·6	–8·4	+5·2	–3·2
4 4 6		+13·0	–0·3	–16·7	–4·0	–5·0	+3·7	–1·3
6 7 7		+ 9·6	–0·3	–11·6	–2·3	–3·9	+1·4	–2·5
7 11 47		+ 8·8	–0·3	– 8·9	–0·4	+1·1	+0·9	+2·0
8 10 28		+ 4·3	–0·3	– 8·6	–4·6	+1·2	+0·9	+2·1
9 14 40		+ 7·3	–0·3	– 9·8	–2·8	–1·0	+0·7	–0·3
10 8 34		+ 7·3	–0·3	–10·1	–3·1	+0·2	+0·5	+0·7
11 13 24		+ 5·0	–0·3	– 9·3	–4·6	+0·9	+0·1	+1·0
12 10 3		+ 3·0	–0·3	– 7·7	–5·0	–3·3	0·0	–3·3
13 12 58		– 0·8	–0·3	– 5·5	–6·6	+4·7	–0·3	+4·4
15 18 1		– 4·1	–0·3	– 5·4	–9·8	+3·3	–1·3	+2·0
16 17 16		+ 2·3	–0·3	– 5·6	–3·6	+2·8	–1·8	+1·0
26 5 57		+19·1	–0·3	–28·2	–9·4	–5·0	+3·5	–1·5
27 6 12		+18·7	–0·3	–25·8	–7·4	–5·0	+4·8	–0·2
28 6 42		+11·9	–0·3	–21·0	–9·4	–6·3	+5·5	–0·8
Mar. 1 6 5		+13·7	–0·3	–16·8	–3·4	–3·0	+5·8	+2·8
2 7 3		+ 9·3	–0·3	–14·8	–5·8	–3·6	+5·4	+1·8
3 9 26		+11·6	–0·3	–15·3	–4·0	–1·4	+4·0	+2·6
4 10 46		+15·2	–0·3	–15·7	–0·8	–8·2	+2·3	–5·9
5 6 2		+12·2	–0·3	–15·1	–3·2	–2·6	+0·9	–1·7
6 5 59		+11·2	–0·3	–13·0	–2·1	–0·6	–0·7	–1·3
7 6 20		+ 7·0	–0·3	–10·3	–3·6	–1·1	–1·7	–2·8

Approx. G.M.T. 1857.			B – O	Longitude. Corr. to B.	H – B	H – O	E.N.P.D. B – O	H – B	H – O
d	h	m							
Mar. 8	7	6	+ 2·5	−0·3	− 8·5	− 6·3	+4·2	−2·4	+1·8
9	6	3	+ 5·0	−0·3	− 8·1	− 3·4	+2·0	−2·5	−0·5
11	15	44	+ 3·5	−0·3	− 8 8	− 5·6	+3·3	−2·0	+1·3
12	10	27	+ 3·1	−0·3	− 8·4	− 5·6	+3·3	−1·8	+1·5
13	10	40	+ 2·5	−0·3	− 7·3	− 5 1	+2·1	−1·4	+0·7
15	13	56	+ 3·6	−0·3	− 5·8	− 2·5	−0·9	−1·0	−1·9
16	14	49	+ 1·6	−0·3	− 5·9	− 4·6	−0·1	−1·2	−1·3
17	17	3	+ 1·5	−0·3	− 6·0	− 4·8	+2·2	−1·6	+0 6
20	17	55	− 4·6	−0·3	− 0·1	− 5·0	+2·5	−2·8	−0·3
28	7	8	+10·0	−0·3	−21·6	−11·9	−3·4	+4·8	+1·4
30	6	49	+11·1	−0·3	−13·6	− 2·8	−4·1	+4·6	+0·5
31	7	18	+ 9·0	−0·3	−11·0	− 2·3	−6·7	+3·4	−3·3
Apr. 2	6	29	+ 4·7	−0·3	−11·3	− 6·9	−2·0	+0·5	−1·5
3	7	47	+11·9	−0·3	−12·1	− 0·5	+3·3	−1·3	+2·0
5	7	46	+ 7·5	−0·3	−10·7	− 3·5	+3·6	−3·7	−0·1
6	7	11	+ 6·6	−0·3	− 9·1	− 2·8	+3·0	−4·0	−1·0
7	6	45	+ 5·6	−0·3	− 8·1	− 2·8	+0·8	−3·7	−2·9
8	8	56	+ 4·5	−0·3	− 7·6	− 3·4	+5·5	−3·0	+2·5
9	10	17	+ 3·9	−0·3	− 8·3	− 4·7	+4·7	−2·3	+2·4
10	11	0	+ 3·6	−0·3	− 9·2	− 5·9	+1·7	−1·3	+0·4
11	11	6	+ 4·4	−0·3	− 9·5	− 5·4	+1·4	−0·7	+0·7
12	16	47	+ 9·2	−0·3	− 9·8	− 0·9	+1·2	+0·3	+1·5
13	16	58	+ 3·3	−0·3	− 9·6	− 6·6	−0·6	+0·6	0·0
14	15	38	+ 6·4	−0·3	− 9·3	− 3·2	−3·2	+0·6	−2·6
15	15	54	+ 2·7	−0·3	− 8·6	− 6·2	−3·1	+0·3	−2·8
16	17	1	+ 3·9	−0·3	− 7·4	− 3·8	−3·2	0·0	−3·2
17	16	17	− 2·6	−0·3	− 5·4	− 8·3	−4·2	−0·1	−4·3
18	16	34	− 2·0	−0·3	− 2·4	− 4·7	−3·4	−0·4	−3·8
19	16	30	− 5·4	−0·3	+ 1·7	− 4·0	−1·8	−0·4	−2·2
20	16	34	− 8·5	−0·3	+ 4·9	− 3·9	−2·2	+0·1	−2·1
28	7	30	+ 5·4	−0·3	− 7·6	− 2·5	−5·5	+3·9	−1·6
30	8	23	+ 4·5	−0·3	− 6·3	− 2·1	−0·4	+1·2	+0·8
May 1	6	12	+ 2·9	−0·3	− 8·5	− 5·9	−0·5	−0·4	−0·9
2	13	41	+10·4	−0·3	− 11·6	− 1·5	+0·2	−2·5	−2·3
3	7	19	+ 7·7	−0·3	−12·3	− 4·9	+2·2	−3·4	−1·2
4	6	59	+ 8·0	−0·3	−11·9	− 4·2	+3·3	−4·2	−0·9
5	9	21	+ 4·9	−0·3	− 9·7	− 5·1	+8·7	−4·1	+4·6
6	7	19	+ 3·7	−0·3	− 7·7	− 4·3	+7·9	−3·6	+4·3
7	7	33	+ 0·5	−0·3	− 6·3	− 6·1	+3·8	−2·7	+1·1
8	8	31	+ 2·7	−0·3	− 6·4	− 4·0	+0·1	−1·6	−1·5
9	10	11	+ 5·2	−0·3	− 7·4	− 2·5	+1·1	−0·3	+0·8

Errors of Hansen's Tables deduced

Approx. G.M.T. 1857.			Longitude.				E.N.P.D.		
			B−0	Corr. to B.	H−B	H−0	B−0	H−B	H−0
d	h	m							
May 11	12	15	+ 6˝·3	− 0˝·3	− 10˝·3	− 4˝·3	− 0˝·6	+ 1˝·7	+ 1˝·1
14	14	39	+ 9·0	− 0·3	− 12 2	− 3·5	− 6·3	+ 2·9	− 3·4
16	15	42	+ 5·8	− 0·3	− 11·0	− 5·5	− 5·6	+ 3·6	− 2·0
17	15	39	+ 9·7	− 0·3	− 7·8	+ 1·6	− 8·0	+ 4·2	− 3·8
18	15	15	+ 0·1	− 0·3	− 2·2	− 2·4	− 8·5	+ 5·2	− 3·3
24	8	27	+ 2·8	− 0·3	− 5·4	− 2·9	− 6·5	+ 8·2	+ 1·7
26	8	23	+ 4·2	− 0·3	− 9·4	− 5·5	− 6·3	+ 6·4	+ 0·1
27	7	54	+ 8·2	− 0·3	− 8·4	− 0·5	− 2·3	+ 5·0	+ 2·7
28	8	28	+ 4·9	− 0·3	− 7·9	− 3·3	− 2·8	+ 3·3	+ 0·5
30	7	55	+ 9·1	− 0·3	− 10·1	− 1·3	+ 0·9	− 0·4	+ 0·5
31	8	16	+13·0	− 0·3	− 11·8	+ 0·9	+ 3·6	− 2·3	+ 1·3
June 1	7	20	+ 8·7	− 0·3	− 12·6	− 4·2	+ 5·4	− 3·6	+ 1·8
2	6	59	+ 4·3	− 0·3	− 12·1	− 8·1	+ 5·4	− 4·2	+ 1·2
3	11	11	+ 2·8	− 0·3	− 9·7	− 7·2	+ 0·5	− 4·0	− 3·5
4	7	31	+ 1·5	− 0·3	− 7·4	− 6·2	+ 3·1	− 3·3	− 0·2
5	8	18	+ 1·3	− 0·3	− 4·9	− 3·9	+ 3·3	− 2·3	+ 1·0
8	11	3	+ 3·2	− 0·3	− 6·3	− 3·4	− 0·2	+ 0·6	+ 0·4
9	14	52	+ 9·7	− 0·3	− 9·0	+ 0·4	− 0·2	+ 1·5	+ 1·3
10	12	57	+10·9	− 0·3	− 11·2	− 0·6	− 4·0	+ 1·8	− 2·2
11	13	8	+10·5	− 0·3	− 13·1	− 2·9	− 2·1	+ 2·6	+ 0·5
12	13	0	+ 9·7	− 0·3	− 14·8	− 5·4	− 7·8	+ 3·5	− 4·3
13	14	10	+10·8	− 0·3	− 15·8	− 5·3	− 9·7	+ 4·7	− 5·0
14	13	23	+11·3	− 0·3	− 15·1	− 4·1	−12·2	+ 6·1	− 6·1
15	14	53	+ 9·4	− 0·3	− 11·6	− 2·5	−10·3	+ 7·3	− 3·0
23	8	58	+12·8	− 0·3	− 14·9	− 2·4	− 5·2	+ 6·4	+ 1·2
24	8	53	+13·4	− 0·3	− 17·1	− 4·0	− 2·2	+ 5·4	+ 3·2
25	8	49	+11·5	− 0·3	− 16·7	− 5·5	− 2·8	+ 4·2	+ 1·4
26	8	21	+13·4	− 0·3	− 14·7	− 1·6	− 2·7	+ 2·9	+ 0·2
27	8	3	+ 8·9	− 0·3	− 12·6	− 4·0	+ 0·3	+ 1·6	+ 1·9
28	8	49	+ 7·3	− 0·3	− 11·1	− 4·1	− 0·6	+ 0·2	− 0·4
29	9	5	+ 3·9	− 0·3	− 10·1	− 6·5	+ 3·8	− 1·0	+ 2·8
30	9	17	+ 6·5	− 0·3	− 10·4	− 4·2	− 0·3	− 1·7	− 2·0
July 2	8	0	+ 5·8	− 0·3	− 9·6	− 4·1	+ 0·8	− 2·0	− 1·2
5	9	40	+ 3·4	− 0·3	− 6·0	− 2·9	− 2·7	− 1·1	− 3·8
6	11	36	+ 4·5	− 0·3	− 7·1	− 2·9	0·0	− 1·0	− 1·0
7	10	52	+ 7·1	− 0·3	− 8·7	− 1·9	− 1·4	− 0·6	− 2·0
8	10	52	+ 6·1	− 0·3	− 10·4	− 4·6	− 1·7	− 0·5	− 2·2
9	11	16	+ 8·5	− 0·3	− 11·9	− 3·7	− 1·9	− 0·1	− 2·0
10	10	54	+11·2	− 0·3	− 12·9	− 2·0	− 2·8	+ 0·8	− 2·0
11	11	50	+13·5	− 0·3	− 13·8	− 0·6	− 8·1	+ 2·1	− 6·0
12	13	18	+13·5	− 0·3	− 14·9	− 1·7	− 6·3	+ 3·7	− 2·6

Approx. G.M.T. 1857			B–O	Longitude. Corr. to B.	H–B	H–O	R.N.P.D. B–O	H–B	H–O
	d	h m	"	"	"	"	"	"	"
July	13	12 9	+ 5·9	−0·3	−14·9	− 9·3	− 5·9	+5·1	−0·8
	14	12 35	+11·5	−0·3	−13·6	− 2·4	−11·9	+6·1	−5·8
	15	14 40	+ 7·3	−0·3	−10·4	− 3·4	− 8·9	+5·9	−3·0
	16	15 35	+ 2·6	−0·3	− 6·7	− 4·4	−10·7	+5·2	−5·5
	18	14 11	+ 8·5	−0·3	− 6·1	+ 2·1	− 6·5	+3·0	−3·5
	23	8 49	+21·5	−0·3	−24·2	− 3·0	− 0·7	+0·3	−0·4
	24	8 24	+14·0	−0·3	−22·0	− 8·3	− 2·9	+0·3	−2·6
	25	7 47	+14·3	−0·3	−17·6	− 3·6	− 3·5	+0·3	−3·2
	26	8 15	+ 7·2	−0·3	−11·9	− 5·0	− 2·9	+0·6	−2·3
	27	7 43	+ 4·6	−0·3	− 9·0	− 4·7	− 0·3	+0·9	+0·6
	28	8 9	− 1·8	−0·3	− 7·0	− 9·1	− 1·1	+0·8	−0·3
	29	8 24	− 1·9	−0·3	− 6·9	− 9·1	− 1·8	+1·0	−0·8
	30	7 59	− 1·0	−0·3	− 7·4	− 8·7	+ 0·4	+1·3	+1·7
	31	7 18	+ 5·3	−0·3	− 7·8	− 2·8	− 1·1	+1·3	+0·2
Aug.	1	7 54	+ 1·5	−0·3	− 8·6	− 7·4	+ 0·8	+1·1	+1·9
	2	8 17	+ 5·4	−0·3	− 9·5	− 4·4	− 1·1	+0·7	−0·4
	3	8 14	+ 8·9	−0·3	−10·7	− 2·1	− 1·5	0·0	−1·5
	4	11 23	+12·7	−0·3	−12·9	− 0·5	+ 0·8	−0·5	+0·3
	5	9 18	+ 7·2	−0·3	−14·1	− 7·2	+ 1·7	−0·8	+0·9
	9	10 56	+ 9·8	−0·3	−10·4	− 0·9	− 6·8	+2·1	−4·7
	11	11 58	+12·2	−0·3	−12·4	− 0·5	− 8·3	+4·0	−4·3
	12	11 13	+13·5	−0·3	−13·3	− 0·1	−10·7	+3·9	−6·8
	14	16 14	+14·2	−0·3	−13·2	+ 0·7	− 6·0	+1·0	−5·0
	23	7 30	+10·9	−0·3	−17·1	− 6·5	+ 1·1	−1·4	−0·3
	24	6 59	+ 8·8	−0·3	−11·8	− 3·3	− 3·8	+0·1	−3·7
	25	7 4	+ 2·0	−0·3	− 7·4	− 5·7	+ 0·3	+1·4	+1·7
	27	7 28	− 2·2	−0·3	− 4·6	− 7·1	− 4·8	+2·7	−2·1
	29	8 10	− 3·5	−0·3	− 6·3	−10·1	− 5·3	+2·8	−2·5
	30	6 35	+ 0·1	−0·3	− 7·4	− 7·6	− 2·8	+2·3	−0·5
	31	8 43	+ 3·6	−0·3	− 9·0	− 5·7	− 3·0	+1·7	−1·3
Sept.	1	8 11	+ 7·4	−0·3	−10·6	− 3·5	− 3·0	+1·3	−1·7
	3	7 53	+12·1	−0·3	−13·2	− 1·4	− 5·2	+0·8	−4·4
	4	8 14	+12·1	−0·3	−13·0	− 1·2	− 3·9	+0·9	−3·0
	5	8 19	+ 8·6	−0·3	−12·2	− 3·9	− 5·2	+1·5	−3·7
	6	8 28	+10·8	−0·3	−11·4	− 0·9	− 7·5	+2·3	−5·2
	7	11 16	+10·0	−0·3	−11·2	− 1·5	− 8·3	+3·3	−5·0
	8	10 5	+12·8	−0·3	−11·8	+ 0·7	− 8·1	+3·8	−4·3
	9	12 43	+15·8	−0·3	−12·9	+ 2·6	− 6·1	+3·8	−2·3
	11	12 58	+18·2	−0·3	−15·5	+ 2·4	− 1·5	+1·6	+0·1
	12	15 11	+17·6	−0·3	−15·5	+ 1·8	− 1·2	−0·4	−1·6
	23	6 11	+ 8·2	−0·3	−10·4	− 2·5	− 4·1	+3·1	−1·0
	24	6 24	+ 1·8	−0·3	− 7·5	− 6·0	− 0·6	+3·6	+3·0

Errors of Hansen's Tables deduced

Approx. G.M.T. 1857.			Longitude.				E.N.P.D.		
d	h	m	B−0	Corr. to B.	H−B	H−0	B−0	H−B	H−0
Sept. 26	6	56	+ 2.9	−0.3	− 5.9	− 3.3	−6.6	+4.0	−2.6
28	6	10	− 2.6	−0.3	− 6.4	− 9.3	−6.7	+3.4	−3.3
29	7	38	+ 3.4	−0.3	− 6.6	− 3.5	−6.8	+3.2	−3.6
30	6	52	− 1.4	−0.3	− 6.4	− 8.1	−4.9	+2.9	−2.0
Oct. 1	6	42	+ 6.0	−0.3	− 6.5	− 0.8	−5.2	+2.8	−2.4
2	6	30	+ 5.5	−0.3	− 7.3	− 2.1	−5.8	+3.0	−2.8
4	16	48	+10.5	−0.3	−12.8	− 2.6	+2.9	+3.1	+6.0
5	7	19	+11.5	−0.3	−13.9	− 2.7	−7.7	+3.3	−4.4
6	8	31	+15.4	−0.3	−15.2	− 0.1	−7.9	+3.1	−4.8
7	9	56	+19.8	−0.3	−15.6	+ 3.9	−6.4	+2.6	−3.8
8	11	33	+18.7	−0.3	−16.1	+ 2.3	−5.8	+1.9	−3.9
9	13	55	+14.8	−0.3	−17.1	− 2.6	−4.1	+0.6	−3.5
13	17	44	+13.3	−0.3	−10.9	+ 2.1	+0.9	−4.0	−3.1
25	6	25	+ 7.8	−0.3	− 9.9	− 2.4	−7.5	+4.5	−3.0
26	5	6	+ 4.6	−0.3	−10.1	− 5.8	−7.4	+4.3	−3.1
27	8	30	+ 6.4	−0.3	−10.5	− 4.4	−4.6	+4.4	−0.2
28	6	2	+ 5.4	−0.3	− 9.6	− 4.5	−5.0	+4.5	−0.5
29	5	16	+ 5.4	−0.3	− 7.8	− 2.7	−5.7	+4.8	−0.9
30	4	52	+ 4.7	−0.3	− 6.2	− 1.8	−8.6	+4.7	−3.9
31	5	47	+ 7.9	−0.3	− 6.6	+ 1.0	−6.0	+4.3	−1.7
Nov. 1	5	47	+ 7.6	−0.3	− 8.8	− 1.5	−7.9	+4.1	−3.8
2	9	9	+12.8	−0.3	−11.9	+ 0.6	−6.6	+3.3	−3.3
4	8	25	+17.3	−0.3	−13.5	+ 3.5	−5.1	+1.5	−3.6
5	11	36	+11.8	−0.3	−13.1	− 1.6	−0.7	+0.1	−0.6
7	16	53	+13.4	−0.3	−14.4	− 1.3	+3.1	−3.4	−0.3
10	14	51	+ 7.2	−0.3	−10.4	− 3.5	+5.4	−6.2	−0.8
11	16	13	+ 1.1	−0.3	− 7.7	− 6.9	+5.2	−5.8	−0.6
21	6	51	+15.0	−0.3	−18.4	− 3.7	−5.1	+2.6	−2.5
22	4	54	+10.5	−0.3	−16.2	− 6.0	−2.7	+2.2	−0.5
24	5	1	+ 4.1	−0.3	−15.5	−11.7	−2.5	+2.5	0.0
26	9	8	+10.6	−0.3	−17.3	− 7.0	−2.8	+4.2	+1.4
27	4	11	+18.5	−0.3	−17.0	+ 1.2	−4.6	+4.6	0.0
28	5	39	+12.1	−0.3	−15.9	− 4.1	−6.0	+4.7	−1.3
29	5	4	+13.4	−0.3	−14.7	− 1.6	−7.7	+4.3	−3.4
30	7	10	+10.3	−0.3	−13.8	− 3.8	−8.1	+3.3	−4.8
Dec. 1	10	18	+10.3	−0.3	−13.4	− 3.4	−3.9	+2.4	−1.5
2	6	10	+14.1	−0.3	−12.3	+ 1.5	−2.0	+1.7	−0.3
3	8	33	+ 8.4	−0.3	−10.4	− 2.3	−2.0	+1.0	−1.0
4	8	19	+ 6.2	−0.3	− 8.7	− 2.8	−2.0	−0.2	−2.2
5	9	33	+ 3.9	−0.3	− 7.7	− 4.1	−2.8	−1.4	−4.2

Approx. G.M.T. 1857			Longitude.				E.N.P.D.		
d	h	m	B−O	Corr. to B.	H−B	H−O	B−O	H−B	H−O
Dec. 6	13	23	+10″.4	−0″.3	− 7″.7	+2″.4	+2″.4	−2″.9	−0″.5
7	12	58	+ 4.6	−0.3	− 8.5	−4.2	+3.6	−4.9	−1.3
8	16	57	+ 6.9	−0.3	− 8.3	−1.7	+5.0	−5.4	−0.4
10	18	56	+ 1.8	−0.3	− 6.7	−5.2	+7.2	−5.2	+2.0
19	4	35	+15.9	−0.3	−21.8	−6.2	+2.0	−0.9	+1.1
20	4	38	+12.5	−0.3	−19.6	−7.4	0.0	−1.4	−1.4
22	7	56	+11.8	−0.3	−14.1	−2.6	+3.3	−1.6	+1.7
23	6	32	+ 8.8	−0.3	−14.3	−5.8	+3.7	−0.6	+3.1
25	4	3	+15.1	−0.3	−19.0	−4.2	−2.7	+1.5	−1.2
27	4	38	+15.6	−0.3	−21.6	−6.3	−4.0	+2.3	−1.7
28	5	13	+12.9	−0.3	−20.5	−7.9	−4.2	+1.9	−2.3
29	8	49	+12.8	−0.3	−18.5	−6.0	−5.6	+1.3	−4.3
30	11	43	+10.5	−0.3	−17.3	−7.1	−0.8	+0.7	−0.1
31	5	33	+12.1	−0.3	−16.9	−5.1	+0.1	+0.9	+1.0

Approx. G.M.T. 1858.			Longitude.				H.N.P.D.		
			B−O	Corr. to B.	H−B	H−O	B−O	H−B	H−O
d	h	m							
Jan. 1	12	54	+ 14˙5	− 0˙3	− 14˙9	− 0˙7	+ 0˙9	+ 0˙4	+ 1˙3
3	21	0	+ 9˙2	− 0˙3	− 9˙3	− 0˙4	+ 2˙8	− 0˙3	+ 2˙5
4	11	37	+ 4˙1	− 0˙3	− 8˙1	− 4˙3	− 2˙2	− 0˙6	− 2˙8
5	20	1	(+ 8˙0)	− 0˙3	− 7˙6	(+0˙1)	(+10˙2)	− 1˙3	(+8˙9)
6	18	38	+ 2˙7	− 0˙3	− 8˙1	− 5˙7	+ 1˙0	− 1˙5	− 0˙5
9	18	2	+ 7˙0	− 0˙3	− 6˙8	− 0˙1	− 1˙0	+ 0˙3	− 0˙7
11	19	20	− 1˙1	− 0˙3	− 3˙6	− 5˙0	− 1˙3	+ 1˙4	+ 0˙1
18	5	12	+ 10˙7	− 0˙3	− 16˙4	− 6˙0	− 0˙2	− 1˙7	− 1˙9
19	4	38	+ 7˙1	− 0˙3	− 12˙9	− 6˙1	+ 3˙6	− 1˙8	+ 1˙8
20	5	13	+ 6˙1	− 0˙3	− 10˙1	− 4˙3	+ 0˙3	− 1˙3	− 1˙0
21	4	31	+ 2˙9	− 0˙3	− 9˙7	− 7˙1	− 2˙6	− 0˙6	− 3˙2
22	5	1	+ 7˙5	− 0˙3	− 11˙6	− 4˙4	− 0˙1	+ 0˙2	+ 0˙1
23	3	43	+ 9˙3	− 0˙3	− 14˙6	− 5˙6	− 4˙6	+ 0˙7	− 3˙9
24	4	19	+ 12˙6	− 0˙3	− 17˙5	− 5˙2	− 2˙5	+ 0˙5	− 2˙0
25	3	18	+ 12˙2	− 0˙3	− 18˙9	− 7˙0	− 2˙0	0˙0	− 2˙0
26	5	2	+ 17˙5	− 0˙3	− 19˙5	− 2˙3	− 4˙0	− 0˙7	− 4˙7
27	4	14	+ 11˙4	− 0˙3	− 19˙7	− 8˙6	+ 1˙0	− 1˙4	− 0˙4
28	8	42	+ 17˙3	− 0˙3	− 20˙0	− 3˙0	+ 2˙6	− 1˙4	+ 1˙2
29	11	30	+ 14˙1	− 0˙3	− 20˙4	− 6˙6	− 1˙1	− 1˙4	− 2˙5
31	10	38	+ 14˙3	− 0˙3	− 17˙6	− 3˙6	+ 1˙7	− 0˙7	+ 1˙0
Feb. 1	10	27	+ 8˙4	− 0˙3	− 15˙5	− 7˙4	− 1˙4	− 0˙1	− 1˙5
3	17	20	+ 12˙4	− 0˙3	− 11˙4	+ 0˙7	− 4˙1	+ 0˙8	− 3˙3
4	15	25	+ 7˙9	− 0˙3	− 11˙0	− 3˙4	− 1˙7	+ 1˙5	− 0˙2
6	17	14	+ 3˙1	− 0˙3	− 9˙6	− 6˙8	− 4˙4	+ 2˙9	− 1˙5
7	18	39	− 1˙4	− 0˙3	− 7˙5	− 9˙2	− 3˙1	+ 3˙1	0˙0
16	6	52	+ 6˙2	− 0˙3	− 14˙8	− 8˙9	− 5˙6	+ 0˙7	− 4˙9
17	6	25	+ 5˙2	− 0˙3	− 13˙1	− 8˙2	+ 1˙9	+ 1˙4	+ 3˙3
18	5	48	+ 12˙0	− 0˙3	− 11˙3	+ 0˙4	− 2˙3	+ 1˙7	− 0˙6
19	7	19	+ 6˙8	− 0˙3	− 11˙1	− 4˙6	+ 4˙6	+ 2˙0	+ 6˙6
20	5	53	+ 6˙2	− 0˙3	− 12˙4	− 6˙5	− 6˙7	+ 2˙2	− 4˙5
21	5	12	+ 9˙8	− 0˙3	− 14˙9	− 5˙4	− 3˙0	+ 1˙6	− 1˙4
22	5	3	+ 14˙6	− 0˙3	− 17˙5	− 3˙2	− 2˙1	+ 0˙4	− 1˙7
24	6	7	+ 16˙3	− 0˙3	− 20˙6	− 4˙6	+ 1˙8	− 2˙6	− 0˙8
25	5	6	+ 15˙3	− 0˙3	− 20˙4	− 5˙4	+ 3˙4	− 3˙2	+ 0˙2
26	5	30	+ 14˙2	− 0˙3	− 18˙6	− 4˙7	+ 2˙7	− 3˙6	− 0˙9
27	7	0	+ 12˙6	− 0˙3	− 16˙4	− 4˙1	+ 0˙5	− 3˙5	− 3˙0
28	11	15	+ 11˙9	− 0˙3	− 15˙2	− 3˙6	+ 1˙1	− 2˙8	− 1˙7

Approx. G.M.T. 1858.			B−O	Longitude. Corr. to B.	H−B	H−O	E.N.P.D. B−O	H−B	H−O
	d	h	m							
Mar.	3	18	22	+ 11·4	−0·3	− 12·3	− 1·2	+ 4·3	+ 0·5	+ 4·8
	6	16	24	+ 6·0	−0·3	− 10·6	− 4·9	− 1·3	+ 2·9	+ 1·6
	8	17	53	+ 2·0	−0·3	− 7·6	− 5·9	− 3·6	+ 2·8	− 0·8
	9	18	13	0·0	−0·3	− 5·0	− 5·3	− 1·9	+ 2·3	+ 0·4
	16	6	51	+ 5·6	−0·3	− 11·6	− 6·3	+ 1·6	+ 0·1	+ 1·7
	18	7	35	+ 9·4	−0·3	− 15·6	− 6·5	− 4·3	+ 1·4	− 2·9
	20	8	55	+ 9·6	−0·3	− 13·7	− 4·4	+ 0·8	+ 1·8	+ 2·6
	21	6	38	+ 12·3	−0·3	− 13·9	− 1·9	− 1·5	+ 1·6	+ 0·1
	22	6	0	+ 14·3	−0·3	− 15·7	− 1·7	− 1·2	+ 0·9	− 0·3
	23	5	34	+ 15·6	−0·3	− 18·8	− 3·5	+ 1·5	− 0·6	+ 0·9
	24	4	57	+ 18·3	−0·3	− 21·4	− 3·4	+ 2·3	− 2·3	0·0
	25	8	16	+ 20·5	−0·3	− 20·9	− 0·7	− 0·8	− 3·6	− 4·4
	26	6	59	+ 15·9	−0·3	− 18·5	− 2·9	+ 4·0	− 4·3	− 0·3
	27	11	59	+ 10·9	−0·3	− 14·0	− 3·4	+ 5·8	− 4·5	+ 1·3
	28	7	12	+ 7·2	−0·3	− 11·2	− 4·3	+ 4·0	− 4·0	0·0
	29	8	13	+ 3·7	−0·3	− 9·5	− 6·1	+ 1·0	− 2·8	− 1·8
	30	12	0	+ 6·1	−0·3	− 9·0	− 3·2	+ 3·2	− 0·9	+ 2·3
Apr.	1	11	58	+ 6·7	−0·3	− 8·3	− 1·9	− 6·0	+ 2·0	− 4·0
	3	15	52	+ 5·9	−0·3	− 8·3	− 2·7	− 6·5	+ 3·6	− 2·9
	15	7	42	+ 8·3	−0·3	− 13·5	− 5·5	− 1·3	− 0·2	− 1·5
	16	7	16	+ 12·4	−0·3	− 15·6	− 3·5	+ 2·2	− 0·1	+ 2·1
	17	7	50	+ 12·2	−0·3	− 14·3	− 2·4	+ 3·6	− 0·1	+ 3·5
	18	7	21	+ 12·2	−0·3	− 11·9	0·0	+ 0·2	− 0·2	0·0
	19	7	31	+ 10·3	−0·3	− 10·9	− 0·9	+ 3·3	− 0·2	+ 3·1
	20	8	21	+ 13·9	−0·3	− 12·2	+ 1·4	+ 1·0	− 1·2	− 0·2
	21	6	6	+ 9·4	−0·3	− 14·6	− 5·5	+ 1·5	− 2·4	− 0·9
	22	5	31	+ 12·8	−0·3	− 16·2	− 3·7	+ 3·0	− 3·8	− 0·8
	23	7	1	+ 10·6	−0·3	− 15·5	− 5·2	+ 7·7	− 4·5	+ 3·2
	24	6	52	+ 12·1	−0·3	− 13·2	− 1·4	+ 5·3	− 4·6	+ 0·7
	25	7	31	+ 10·5	−0·3	− 10·5	− 0·3	− 2·5	− 3·8	− 6·3
	26	7	33	+ 4·6	−0·3	− 8·9	− 4·6	+ 0·7	− 2·5	− 1·8
	28	10	3	+ 2·5	−0·3	− 8·5	− 6·3	− 2·9	+ 1·4	− 1·5
	30	12	23	+ 2·1	−0·3	− 7·3	− 5·5	− 4·2	+ 4·1	− 0·1
May	4	15	53	+ 7·1	−0·3	− 8·4	− 1·6	− 7·5	+ 5·6	− 1·9
	5	16	7	− 0·7	−0·3	− 8·4	− 9·4	− 7·9	+ 5·5	− 2·4
	6	15	46	+ 1·2	−0·3	− 6·5	− 5·6	− 12·2	+ 5·5	− 6·7
	7	16	15	− 4·1	−0·3	− 2·3	− 6·7	− 10·5	+ 5·4	− 5·1
	15	8	16	+ 12·9	−0·3	− 17·3	− 4·7	+ 2·7	+ 1·5	+ 4·2
	16	8	40	+ 13·9	−0·3	− 15·7	− 2·1	+ 4·3	+ 1·0	+ 5·3
	18	7	32	+ 7·4	−0·3	− 9·7	− 2·6	− 1·4	− 0·4	− 1·8
	19	7	6	+ 8·8	−0·3	− 8·6	− 0·1	+ 0·3	− 1·5	− 1·2
	20	8	19	+ 9·6	−0·3	− 8·7	+ 0·6	+ 2·6	− 2·8	− 0·2

Errors of Hansen's Tables deduced

Approx. G.M.T. 1858.			Longitude.				E.N.P.D.		
			B−O	Corr. to B.	H−B	H−O	B−O	H−B	H−O
d	h	m							
May 22	7	2	+ 4″·5	−0″·3	− 9″·3	− 5″·1	+ 4″·4	−3″·6	+0″·8
23	8	23	+ 3·5	−0·3	− 8·8	− 5·6	+ 5·7	−3·3	+2·4
25	7	38	+ 4·3	−0·3	− 8·1	− 4·1	+ 1·6	−0·3	+1·3
26	13	3	+ 9·0	−0·3	− 8·2	+ 0·5	− 3·5	+1·5	−2·0
27	12	3	+ 5·2	−0·3	− 8·3	− 3·4	− 0·5	+2·8	+2·3
28	12	2	+ 7·0	−0·3	− 8·2	− 1·5	− 6·3	+3·8	−2·5
30	15	32	+ 4·3	−0·3	− 7·5	− 3·5	− 5·9	+5·1	−0·8
June 1	15	17	+ 5·5	−0·3	− 8·5	− 3·3	− 1·9	+5·5	+3·6
3	15	8	+ 3·9	−0·3	− 9·5	− 5·9	− 9·9	+7·0	−2·9
7	14	49	− 10·8	−0·3	+ 0·5	−10·6	−15·9	+9·0	−6·9
8	15	53	+ 2·0	−0·3	+ 0·6	+ 2·3	−13·8	+8·3	−5·5
12	8	53	+13·5	−0·3	−21·1	− 7·9	− 6·4	+4·1	−2·3
13	8	36	+23·8	−0·3	−24·0	− 0·5	− 1·2	+3·1	+1·9
14	9	50	+19·7	−0·3	−22·3	− 2·9	− 0·3	+2·1	+1·8
15	8	34	+12·6	−0·3	−17·9	− 5·6	− 1·3	+1·1	−0·2
16	8	10	+10·3	−0·3	−13·1	− 3·1	+ 1·1	+0·1	+1·2
17	9	13	+ 7·1	−0·3	− 9·3	− 2·5	+ 1·4	−0·7	+0·7
18	7	27	+ 5·3	−0·3	− 8·3	− 3·3	+ 2·1	−0·9	+1·2
19	8	14	+ 4·2	−0·3	− 8·2	− 4·3	0·0	−1·1	−1·1
21	7	27	+ 4·5	−0·3	− 8·4	− 4·2	− 1·8	+0·5	−1·3
22	8	30	+ 0·6	−0·3	− 8·0	− 7·7	+ 0·3	+1·7	+2·0
23	8	47	+ 0·3	−0·3	− 6·5	− 6·5	− 0·1	+2·9	+2·8
24	9	42	+ 6·1	−0·3	− 5·6	+ 0·2	− 4·8	+3·5	−1·3
25	10	25	+ 8·7	−0·3	− 5·4	+ 3·0	− 7·2	+3·7	−3·5
27	12	5	+ 0·9	−0·3	− 6·9	− 6·3	− 2·2	+3·4	+1·2
28	11	33	+ 9·1	−0·3	− 8·0	+ 0·8	− 5·7	+3·2	−2·5
29	11	45	+ 5·3	−0·3	− 9·2	− 4·2	− 9·2	+3·5	−5·7
30	12	42	+ 7·9	−0·3	−10·2	− 2·6	− 1·0	+3·8	+2·8
July 1	13	32	+ 8·6	−0·3	−11·0	− 2·7	− 8·7	+4·8	−3·9
6	13	53	+ 4·5	−0·3	− 7·6	− 3·4	−12·1	+5·8	−6·3
14	8	36	+21·4	−0·3	−22·5	− 1·4	+ 1·5	−1·3	+0·2
16	8	27	+ 7·6	−0·3	−12·6	− 5·3	+ 0·3	0·0	+0·3
17	8	53	+ 4·4	−0·3	−10·3	− 6·2	− 0·1	+0·9	+0·8
18	7	2	+ 8·0	−0·3	− 9·6	− 1·9	− 2·7	+2·2	−0·5
19	8	19	+ 4·4	−0·3	− 9·6	− 5·5	− 6·2	+3·3	−2·9
21	7	47	+ 4·7	−0·3	− 7·7	− 3·3	− 7·6	+5·0	−2·6
25	10	27	+ 1·2	−0·3	− 5·1	− 4·2	− 5·6	+3·8	−1·8
26	10	42	+ 7·9	−0·3	− 6·6	+ 1·0	− 1·4	+3·0	+1·6
28	10	9	+ 3·4	−0·3	− 8·8	− 5·7	− 9·1	+2·2	−6·9
29	10	43	+ 7·1	−0·3	− 9·8	− 3·0	− 6·9	+2·5	−4·4
30	11	58	+11·1	−0·3	−10·8	0·0	− 4·9	+2·8	−2·1
31	10	59	+11·3	−0·3	−13·1	− 2·1	− 9·0	+3·2	−5·8

Approx. G.M.T. 1858.			B−O	Longitude. Corr. to B.	H−B	H−O	B−O	E.N.P.D. H−B	H−O
	d	h	m	″	″	″	″	″	″	″
Aug.	1	11	27	+15·3	−0·3	−15·5	−0·5	−8·6	+3·2	−5·4
	2	17	46	+17·7	−0·3	−16·5	+0·9	−6·6	+2·9	−3·7
	3	11	48	+12·6	−0·3	−15·3	−3·0	−6·7	+2·0	−4·7
	5	14	13	+ 6·9	−0·3	− 8·1	−1·5	−3·7	−1·1	−4·8
	6	15	45	+ 7·4	−0·3	− 9·0	−1·9	−4·1	−2·7	−6·8
	13	7	23	+18·2	−0·3	−19·8	−1·9	+2·0	−3·1	−1·1
	16	8	1	+ 6·1	−0·3	− 8·8	−3·0	−3·1	+2·8	−0·3
	20	8	16	− 3·0	−0·3	− 5·7	−9·0	−3·6	+5·8	+2·2
	22	9	3	− 1·2	−0·3	− 5·3	−6·8	−5·2	+4·8	−0·4
	23	8	31	+ 2·1	−0·3	− 6·2	−4·4	−5·1	+3·9	−1·2
	24	9	5	+ 5·2	−0·3	− 7·3	−2·4	−4·3	+3·1	−1·2
	25	8	37	+ 3·9	−0·3	− 7·5	−3·9	−9·9	+2·6	−7·3
	26	9	4	+ 4·9	−0·3	− 7·3	−2·7	−9·0	+2·1	−6·9
	27	9	14	+ 3·6	−0·3	− 7·2	−3·9	−5·3	+2·1	−3·2
	28	9	48	+ 8·4	−0·3	− 8·6	−0·5	−8·2	+2·5	−5·7
	29	9	59	+12·4	−0·3	−11·3	+0·8	−6·2	+2·2	−4·0
	30	9	53	+13·5	−0·3	−14·3	−1·1	−7·0	+2·1	−4·9
	31	11	2	+15·6	−0·3	−16·2	−0·9	−4·3	+1·6	−2·7
Sept.	1	11	25	+16·5	−0·3	−15·4	+0·8	−3·8	+0·1	−3·7
	12	6	23	+15·7	−0·3	−16·6	−1·2	+2·3	−1·3	+1·0
	13	6	53	+ 7·5	−0·3	−11·2	−4·0	−1·8	+0·6	−1·2
	15	6	58	− 0·2	−0·3	− 4·7	−5·2	−5·8	+3·0	−2·8
	16	6	14	+ 0·5	−0·3	− 4·0	−3·8	−5·7	+3·7	−2·0
	17	6	12	− 0·9	−0·3	− 4·0	−5·2	−5·2	+4·4	−0·8
	18	6	59	− 2·3	−0·3	− 4·0	−6·6	−6·8	+4·6	−2·2
	20	7	55	+ 0·1	−0·3	− 4·6	−4·8	−7·3	+4·6	−2·7
	21	7	32	+ 3·3	−0·3	− 6·2	−3·2	−8·0	+4·3	−3·7
	22	7	36	+ 5·7	−0·3	− 7·7	−2·3	−7·4	+3·7	−3·7
	23	8	31	+ 7·7	−0·3	− 8·9	−1·5	−7·0	+2·9	−4·1
	24	7	30	+10·1	−0·3	− 9·4	+0·4	−9·2	+2·5	−6·7
	25	7	56	+ 7·2	−0·3	− 9·8	−2·9	−7·7	+2·1	−5·6
	27	9	33	+ 9·7	−0·3	−11·5	−2·1	−6·4	+1·6	−4·8
	28	19	28	+14·1	−0·3	−13·7	+0·1	−2·2	+1·2	−1·0
	29	16	0	+17·4	−0·3	−15·0	+2·1	−2·8	+0·7	−2·1
	30	11	37	+14·6	−0·3	−15·7	−1·4	+0·3	−0·5	−0·2
Oct.	2	14	42	+10·3	−0·3	−14·1	−4·1	+2·2	−3·9	−1·7
	4	17	36	+11·8	−0·3	−14·7	−3·2	+4·0	−6·2	−2·2
	15	6	21	− 3·5	−0·3	− 4·1	−7·9	−5·0	+4·3	−0·7
	16	6	3	+ 0·7	−0·3	− 3·4	−3·0	−6·9	+5·0	−1·9
	17	6	12	− 3·6	−0·3	− 3·1	−7·0	−9·4	+5·6	−3·8
	20	8	51	+ 0·5	−0·3	− 6·2	−6·0	−6·1	+6·0	−0·1
	21	14	24	+ 3·6	−0·3	− 9·9	−6·6	−5·2	+4·9	−0·3

Errors of Hansen's Tables deduced

Approx. G.M.T. 1858.			Longitude.			E.N.P.D.		
		B–0	Corr. to B.	H–B	H–0	B–0	H–B	H–0
	d h m	"	"	"	"	"	"	"
Oct. 22 6 13	+ 8·1	–0·3	–11·9	–4·1	–4·6	+4·1	–0·5
25 7 39	+10·2	–0·3	–14·4	–4·5	–3·6	+0·1	–3·5
26 8 57	+14·6	–0·3	–13·8	+0·5	–1·2	–0·6	–1·8
27 9 46	+14·4	–0·3	–14·3	–0·2	+1·5	–1·8	–0·3
28 11 29	+16·3	–0·3	–15·4	+0·6	+3·8	–3·4	+0·4
29 14 26	+16·6	–0·3	–16·5	–0·2	+2·6	–5·1	–2·5
30 18 22	+17·1	–0·3	–15·9	+0·9	+3·8	–6·6	–2·8
31 16 50	+11·4	–0·3	–14·7	–3·6	+5·5	–7·3	–1·8
Nov. 1 17 41	+13·1	–0·3	–13·1	–0·3	+5·6	–7·2	–1·6
2 17 50	+ 6·8	–0·3	–13·1	–5·6	+6·8	–6·0	+0·8
9 4 50	+15·1	–0·3	–20·7	–5·9	–6·1	+3·3	–2·8
11 4 51	+ 7·5	–0·3	–11·6	–4·4	–5·7	+4·1	–1·6
12 4 37	+ 4·8	–0·3	– 9·1	–4·6	–5·9	+4·5	–1·4
14 5 46	+ 5·6	–0·3	– 8·0	–2·7	–7·1	+6·0	–1·1
15 5 26	+ 3·4	–0·3	– 8·4	–5·3	–6·3	+6·9	+0·6
17 5 45	+ 8·9	–0·3	–10·3	–1·7	–8·0	+7·5	–0·5
18 4 28	+ 9·6	–0·3	–11·7	–2·4	–6·0	+7·0	+1·0
19 14 54	+ 7·3	–0·3	–14·4	–7·4	–3·4	+5·3	+1·9
20 6 35	+13·9	–0·3	–15·7	–2·1	–7·2	+4·2	–3·0
21 6 26	+14·8	–0·3	–16·7	–2·2	–5·1	+2·5	–2·6
22 6 29	+14·3	–0·3	–16·4	–2·4	–3·1	+0·6	–2·5
23 7 28	+13·0	–0·3	–15·2	–2·5	–0·5	–0·9	–1·4
26 11 35	+14·0	–0·3	–13·9	–0·2	+4·6	–7·3	–2·7
28 17 49	+17·0	–0·3	–14·7	+2·0	+7·2	–9·2	–2·0
Dec. 1 18 44	+ 9·8	–0·3	–10·0	–0·5	+7·8	–5·0	+2·8
2 19 16	+ 2·7	–0·3	–10 5	–8·1	+7·0	–2·8	+4·2
15 6 41	+13·7	–0·3	–18·6	–5·2	–5·9	+4·7	–1·2
17 10 38	+16·7	–0·3	–21·6	–5·2	–4·4	+3·6	–0·8
18 6 51	+17·4	–0·3	–21·4	–4·3	–1·1	+2·7	+1·6
19 8 28	+14·4	–0·3	–21·6	–7·5	+4·8	+1·4	+6·2
20 5 6	+15·7	–0·3	–20·9	–5·5	+0·5	+0·2	+0·7
21 10 35	+17·4	–0·3	–19·0	–1·9	–2·3	–1·1	–3·4
22 7 55	+10·9	–0·3	–16·2	–5·6	0·0	–2·1	–2·1
23 10 26	+ 6·6	–0·3	–12·5	–6·2	–0·8	–3·4	–4·2
24 15 23	+ 7·8	–0·3	–10·4	–2·9	+3·2	–4·7	–1·5
25 12 15	+ 7·1	–0·3	–10·4	–3·6	+2 6	–5·5	–2·9
26 16 9	+ 8·6	–0·3	–12·0	–3·7	+6 0	–5·5	+0·5
28 18 27	+11·6	–0·3	–11·3	0·0	+5 8	–2·8	+3·0

Approx. G.M.T. 1859.			Longitude.				E.N.P.D.		
			B–O	Corr. to B.	H–B	H–O	B–O	H–B	H–O
d	h	m							
Jan. 8	5	9	+ 9·7	–0·3	–12·7	– 3·3	+2·5	–0·4	+2·1
9	6	52	+ 4·0	–0·3	– 9·8	– 6·1	+4·7	–0·7	+4·0
10	5	38	+ 3·7	–0·3	– 8·7	– 5·3	–0·5	–0·6	–1·1
12	7	13	+ 8·9	–0·3	–13·0	– 4·4	–2·9	+0·2	–2·7
13	7	53	+15·0	–0·3	–17·3	– 2·6	–1·1	+0·3	–0·8
14	6	27	+13·9	–0·3	–20·9	– 7·3	–1·1	+0·2	–0·9
15	4	3	+17·0	–0·3	–23·1	– 6·4	–0·1	–0·2	–0·3
16	4	36	+18·6	–0·3	–24·4	– 6·1	+2·7	–1·1	+1·6
18	11	0	+20·6	–0·3	–25·6	– 5·3	+1·6	–2·8	–1·2
19	7	9	+19·4	–0·3	–25·1	– 6·0	+3·2	–3·1	+0·1
20	17	34	+23·0	–0·3	–21·0	+ 1·7	+1·5	–3·3	–1·8
21	12	2	+17·7	–0·3	–17·8	– 0·4	–1·1	–2·8	–3·9
22	11	18	+ 5·3	–0·3	–14·6	– 9·6	+1·7	–2·3	–0·6
23	12	6	+ 7·1	–0·3	–12·6	– 5·8	–1·9	–1·1	–3·0
25	17	35	+11·3	–0·3	–11·6	– 0·6	–1·3	+2·3	+1·0
28	19	16	+ 1·3	–0·3	– 3·2	– 2·2	–5·0	+6·0	+1·0
Feb. 5	5	34	+ 6·0	–0·3	–10·0	– 4·3	–0·3	+1·3	+1·0
6	5	22	+ 4·1	–0·3	– 9·2	– 5·4	–0·3	+0·7	+0·4
7	4	58	+ 3·0	–0·3	– 7·3	– 4·6	+1·5	+0·4	+1·9
8	6	17	– 2·2	–0·3	– 5·3	– 7·8	–1·5	+0·5	–1·0
10	9	56	+ 3·8	–0·3	– 7·8	– 4·3	–2·3	+1·0	–1·3
11	4	48	+ 6·7	–0·3	–11·0	– 4·6	+1·2	+0·7	+1·9
12	5	24	+11·6	–0·3	–15·8	– 4·5	–4·3	–0·1	–4·4
13	5	18	+17·3	–0·3	–19·8	– 2·8	+0·8	–1·2	–0·4
14	5	5	+18·5	–0·3	–22·5	– 4·3	+2·7	–2·6	+0·1
15	8	18	+18·6	–0·3	–24·4	– 6·1	+2·5	–3·9	–1·4
16	8	45	+23·0	–0·3	–25·3	– 2·6	+4·7	–4·9	–0·2
17	11	37	+21·6	–0·3	–25·0	– 3·7	+5·0	–4·9	+0·1
18	10	39	+26·0	–0·3	–23·5	+ 2·2	+2·4	–4·5	–2·1
20	16	32	+11·7	–0·3	–17·2	– 5·8	+4·4	–1·2	+3·2
22	15	7	+10·1	–0·3	–13·0	– 3·2	–4·6	+2·2	–2·4
23	16	2	+ 9·2	–0·3	–11·8	– 2·9	–4·9	+4·0	–0·9
24	18	0	+ 7·8	–0·3	–10·5	– 3·0	–5·6	+5·3	–0·3
25	18	8	+ 2·9	–0·3	– 8·6	– 6·0	–9·4	+6·3	–3·1
Mar. 7	6	52	– 4·1	–0·3	– 5·8	–10·2	+0·7	+1·5	+2·2
8	6	7	+ 1·5	–0·3	– 6·1	– 4·9	–0·2	+1·8	+1·6
9	5	34	+ 3·8	–0·3	– 6·2	– 2·7	–1·0	+2·2	+1·2

m

Approx. G.M.T. 1859.			Longitude.				R.N.P.D.		
			B−O	Corr. to B.	H−B	H−O	B−O	H−B	H−O
	d	h m	″	″	″	″	″	″	″
Mar.	10	5 48	+ 2·7	−0·3	− 7·4	−5·0	− 2·0	+2·4	+0·4
	13	11 38	+14·0	−0·3	−20·1	−6·4	+ 4·3	0·0	+4·3
	14	6 37	+14·9	−0·3	−22·0	−7·4	+ 1·9	−1·5	+0·4
	15	8 50	+17·3	−0·3	−22·6	−5·6	+ 4·9	−3·8	+1·1
	16	6 58	+17·4	−0·3	−21·0	−3·9	+ 2·4	−5·3	−2·9
	17	16 7	+13·7	−0·3	−18·0	−4·6	+ 8·1	−6·2	+1·9
	18	8 9	+12·1	−0·3	−16·7	−4·9	+ 7·5	−6·1	+1·4
	19	9 40	+ 8·6	−0·3	−14·8	−6·5	+ 6·5	−5·1	+1·4
	21	11 33	+ 7·1	−0·3	−12·6	−5·8	+ 0·5	−1·6	−1·1
Apr.	6	7 9	+ 4·3	−0·3	− 7·4	−3·4	− 1·6	+0·8	−0·8
	7	7 25	+ 6·3	−0·3	−10·3	−4·3	− 3·2	+0·9	−2·3
	9	8 5	+16·2	−0·3	−17·5	−1·6	+ 0·2	+0·3	+0·5
	10	7 34	+19·7	−0·3	−21·1	−1·7	+ 2·8	−0·9	+1·9
	11	9 20	+22·0	−0·3	−23·6	−1·9	− 0·7	−2·7	−3·4
	13	6 26	+17·5	−0·3	−22·6	−5·4	+ 9·8	−5·9	+3·9
	15	8 34	+14·4	−0·3	−14·1	0·0	+ 6·8	−6·1	+0·7
	16	8 45	+ 7·1	−0·3	−10·2	−3·4	+ 1·1	−5·1	−4·0
	17	9 26	+ 2·5	−0·3	− 7·8	−5·6	− 1·1	−3·7	−4·8
	18	11 9	+ 2·9	−0·3	− 7·2	−4·6	− 0·6	−2·0	−2·6
	19	12 47	+ 0·4	−0·3	− 7·7	−7·6	− 0·1	−0·4	−0·5
	21	14 54	+ 1·3	−0·3	− 8·8	−7·8	− 1·8	+2·7	+0·9
	22	14 54	+ 2·7	−0·3	− 9·6	−7·2	− 3·7	+3·9	+0·2
	25	16 26	+ 3·2	−0·3	− 6·3	−3·4	− 7·2	+6·1	−1·1
May	4	7 55	+ 5·9	−0·3	−11·0	−5·4	+ 3·9	+1·0	+4·9
	5	7 50	+10·7	−0·3	−16·4	−6·0	+ 2·0	+0·2	+2·2
	6	7 45	+16·9	−0·3	−18·9	−2·3	+ 5·4	−0·6	+4·8
	7	7 53	+15·7	−0·3	−19·4	−4·0	+ 2·9	−1·4	+1·5
	8	7 24	+15·1	−0·3	−18·8	−4·0	+ 2·6	−2·6	0·0
	9	7 41	+11·1	−0·3	−18·2	−7·4	+ 2·5	−4·0	− 1·5
	10	8 20	+17·6	−0·3	−18·3	−1·0	+ 4·4	−5·1	−0·7
	11	9 31	+14·9	−0·3	−18·7	−4·1	+ 4·7	−6·1	−1·4
	12	7 1	+14·3	−0·3	−18·0	−4·0	+ 6·4	−6·0	+0·4
	13	7 27	+11·9	−0·3	−16·1	−4·5	+ 7·8	−5·1	+2·7
	14	7 41	+10·2	−0·3	−13·2	−3·3	+ 4·3	−3·8	+0·5
	15	13 48	+ 2·3	−0·3	−10·2	−8·2	+ 2·0	−2·2	−0·2
	21	16 41	+ 2·2	−0·3	− 7·3	−5·4	− 4·0	+4·3	+0·3
	22	14 48	− 1·4	−0·3	− 6·6	−8·3	− 8·9	+5·4	−3·5
	23	14 26	+ 3·4	−0·3	− 6·1	−3·0	− 7·6	+6·5	−1·1
	24	14 46	− 1·0	−0·3	− 4·5	−5·8	−11·6	+7·6	−4·0
	26	15 20	− 4·7	−0·3	+ 0·8	−4·2	−13·7	+9·0	−4·7

Approx. G.M.T. 1859.			Longitude.				R.N.P.D.		
			B−O	Corr. to B.	H−B	H−O	B−O	H−B	H−O
d	h	m	"	"	"	"	"	"	"
June 5	7	57	+23·1	−0·3	−24·9	−2·1	+ 5·4	−1·8	+3·6
6	8	2	+13·0	−0·3	−18·9	−6·2	+ 3·0	−2·7	+0·3
7	8	10	+ 8·5	−0·3	−14·7	−6·5	+ 4·3	−3·3	+1·0
8	8	17	+ 7·6	−0·3	−13·2	−5·9	+ 2·5	−3·7	−1·2
9	7	51	+10·0	−0·3	−12·8	−3·1	+ 4·5	−3·0	+1·5
11	8	3	+ 2·1	−0·3	−11·6	−9·8	+ 2·1	−0·8	+1·3
12	9	3	+ 3·6	−0·3	−10·7	−7·4	+ 0·6	+0·6	+1·2
14	10	1	+ 8·8	−0·3	−11·0	−2·5	+ 0·4	+2·1	+2·5
15	11	2	+ 5·9	−0·3	−11·7	−6·1	− 4·5	+2·7	−1·8
16	12	13	+10·3	−0·3	−11·4	−1·4	− 1·6	+2·8	+1·2
17	11	55	+ 5·9	−0·3	− 9·7	−4·1	− 3·1	+2·8	−0·3
20	13	45	− 1·1	−0·3	− 4·1	−5·5	− 0·9	+3·6	+2·7
21	18	31	+ 0·2	−0·3	− 4·6	−4·7	+ 0·8	+4·7	+5·5
22	15	48	+ 1·9	−0·3	− 5·6	−4·0	− 8·2	+5·8	−2·4
23	16	29	+ 4·0	−0·3	− 6·7	−3·0	− 6·2	+6·7	+0·5
24	14	58	+ 2·6	−0·3	− 7·3	−5·0	−11·2	+7·3	−3·9
July 4	8	34	+25·6	−0·3	−28·9	−3·6	+ 2·2	−1·8	+0·4
5	8	30	+16·6	−0·3	−21·7	−5·4	+ 2·3	−1·8	+0·5
6	8	47	+ 9·5	−0·3	−16·4	−7·2	+ 2·5	−1·3	+1·2
7	9	50	+ 9·7	−0·3	−13·0	−3·6	− 1·0	−0·1	−1·1
8	8	53	+ 8·0	−0·3	−10·9	−3·2	+ 1·2	+1·1	+2·3
9	8	41	− 0·5	−0·3	− 9·1	−9·9	− 0·1	+2·6	+2·5
10	9	26	+ 1·8	−0·3	− 7·7	−6·2	− 3·4	+3·6	+0·2
11	8	25	− 1·0	−0·3	− 6·8	−8·1	− 4·5	+4·3	−0·2
12	10	1	+ 7·2	−0·3	− 7·0	−0·1	− 4·6	+4·4	−0·2
13	12	2	+ 0·9	−0·3	− 7·8	−7·2	− 5·8	+4·1	−1·7
14	11	28	− 1·1	−0·3	− 8·4	−9·8	− 3·6	+3·5	−0·1
15	10	46	+ 3·3	−0·3	− 8·5	−5·5	− 1·4	+2·9	+1·5
16	10	30	+ 5·1	−0·3	− 7·7	−2·9	− 3·6	+2·1	−1·5
17	10	52	− 1·2	−0·3	− 6·3	−7·8	− 3·9	+1·5	−2·4
19	11	14	+ 2·8	−0·3	− 5·2	−2·7	− 4·3	+1·1	−3·2
20	11	19	+ 4·7	−0·3	− 6·9	−2·5	− 3·2	+1·5	−1·7
21	12	14	+ 5·6	−0·3	− 9·6	−4·3	− 5·6	+1·8	−3·8
22	13	50	+ 7·0	−0·3	−12·4	−5·7	− 4·0	+2·7	−1·3
23	14	49	+11·8	−0·3	−14·0	−2·5	− 6·0	+3·3	−2·7
24	13	20	+13·4	−0·3	−13·5	−0·4	− 6·3	+2·9	−3·4
Aug. 4	7	56	+14·7	−0·3	−19·8	−5·4	+ 1·9	−1·2	+0·7
5	8	13	+12·6	−0·3	−14·9	−2·6	− 1·2	+0·4	−0·8
11	8	32	− 2·6	−0·3	− 3·8	−6·7	− 6·4	+4·0	−2·4
12	9	3	− 1·0	−0·3	− 3·8	−5·1	− 3·1	+3·5	+0·4
13	8	49	+ 0·8	−0·3	− 4·2	−3·7	− 3·6	+2·5	−1·1
14	8	29	+ 0·6	−0·3	− 5·1	−4·8	− 1·6	+1·8	+0·2

m 2

Approx. G.M.T. 1859.			Longitude.				E.N.P.D.		
			B−0	Corr. to B.	H−B	H−0	B−0	H−B	H−0
d	h	m	"	"	"	"	"	"	"
Aug. 15	9	14	+ 3·5	−0·3	− 6·2	− 3·0	−6·2	+0·8	−5·4
16	9	55	+ 3·6	−0·3	− 7·2	− 3·9	−4·8	+0·4	−4·4
17	10	15	+ 6·1	−0·3	− 8·9	− 3·1	−2·9	0·0	−2·9
18	13	37	+ 9·3	−0·3	−10·7	− 1·7	−2·5	0·0	−2·5
19	10	18	+ 8·9	−0·3	−12·6	− 4·0	−3·5	+0·6	−2·9
20	10	41	+16·7	−0·3	−14·7	+ 1·7	−5·2	+0·7	−4·5
21	12	2	+10·0	−0·3	−16·0	− 6·3	−1·5	+0·6	−0·9
22	11	43	+12·3	−0·3	−15·4	− 3·4	−6·8	+0·3	−6·5
23	12	42	+10·7	−0·3	−12·9	− 2·5	−2·3	0·0	−2·3
24	14	4	+ 6·4	−0·3	−10·9	− 4·8	−1·6	−1·2	−2·8
Sept. 3	6	54	+17·5	−0·3	−16·6	+ 0·6	+0·3	−1·0	−0·7
4	7	41	+ 7·5	−0·3	−12·5	− 5·3	+0·8	+0·3	+1·1
5	8	23	+ 6·1	−0·3	−10·0	− 4·2	+0·2	+1·5	+1·7
6	7	41	+ 8·7	−0·3	− 8·5	− 0·1	−1·2	+2·4	+1·2
7	7	10	− 0·2	−0·3	− 7·0	− 7·5	−3·7	+3·0	−0·7
9	7	27	+ 2·9	−0·3	− 4·6	− 2·0	−6·5	+3·1	−3·4
10	7	33	+ 3·0	−0·3	− 4·5	− 1·8	−5·5	+2·5	−3·0
11	7	24	+ 4·6	−0·3	− 6·0	− 1·7	−7·3	+2·2	−5·1
12	9	9	− 1·1	−0·3	− 8·2	− 9·6	−3·7	+1·6	−2·1
13	15	24	+ 7·1	−0·3	−10·5	− 3·7	−1·5	+0·7	−0·8
14	10	20	+10·0	−0·3	−11·3	− 1·6	−0·3	+0·4	+0·1
15	8	53	+12·6	−0·3	−11·7	+ 0·6	−1·7	+0·2	−1·5
16	9	49	+12·1	−0·3	−11·3	+ 0·5	−2·7	+0·7	−2·0
17	8	51	+ 9·7	−0 3	−12·1	− 2·7	−6·8	+1·1	−5·7
18	21	23	+14·1	−0·3	−15·1	− 1·3	+0·1	+1·2	+1·3
19	10	40	+12·8	−0·3	−16·2	− 3·7	−4·2	+1·1	−3·1
20	12	1	+14·4	−0·3	−16·6	− 2·5	−1·8	+0·5	−1·3
21	12	3	+10·4	−0·3	··14·4	− 4·3	+2·7	−0·8	+1·9
Oct. 1	5	56	+21·0	−0·3	−24·1	− 3·4	+3·8	−1·0	+2·8
3	6	21	+ 4·9	−0 3	−13·3	− 8·7	−4·2	+1·1	−3·1
4	5	16	+ 3·3	−0·3	−10·4	− 7·4	−1·5	+2·0	+0·5
5	8	48	+ 2·1	−0·3	− 8·7	− 6·9	+3·1	+2·8	+5·9
6	6	29	− 1·9	−0·3	− 7·8	−10·0	−6·5	+3·6	−2·9
8	6	11	+ 2·7	−0·3	− 7·2	− 4·8	−3·0	+4·0	+1·0
10	8	48	+ 7·8	−0·3	−11·5	− 4·0	−1·5	+3·2	+1·7
11	8	17	+11·0	−0·3	−14·5	− 3·8	−3·5	+2·7	−0·8
12	8	22	+13·3	−0·3	−16·4	− 3·4	−5·8	+2·0	−3·8
13	7	35	+15·3	−0·3	−16·0	− 1·0	−1 3	+1·5	+0·2
14	11	33	+13·3	−0·3	−13·8	− 0·8	··4·0	+1·4	··2·6
15	9	40	+12·0	−0·3	−12·4	− 0·7	−2·0	+1·1	−0·9
16	15	31	+13·3	−0·3	−12·7	+ 0·3	−1·7	+0·8	−0·9
17	9	43	+13·6	−0·3	−14·2	− 0·9	+0·2	+0·3	+0·5
19	12	35	+14·8	−0·3	−17·5	− 3·0	+0·7	−2·1	−1·4
20	16	52	+ 8·5	−0·3	−16·0	− 7·8	+5·3	−3·3	+2·0
21	16	26	+ 6·0	−0·3	−14·3	− 8·6	+1·5	−3·8	−2·3
23	17	37	+15·5	−0·3	−17·1	− 1·9	+9·0	−3·2	+5·8

Approx. G.M.T. 1859			Longitude.				M.N.P.D.		
			B–O	Corr. to B.	H–B	H–O	B–O	H–B	H–O
d	h	m	"	"	"	"	"	"	"
Nov. 1	5	5	+ 5·6	−0·3	− 11·5	− 6·2	− 4·4	+3·7	−0·7
3	4	57	− 1·4	−0·3	− 6·3	− 8·0	− 4·6	+4·6	0·0
4	6	11	− 4·7	−0·3	− 6·3	−11·3	− 4·8	+5·3	+0·5
5	10	15	+ 0·4	−0·3	− 7·3	− 7·2	− 6·2	+5·7	−0·5
6	5	6	+ 3·5	−0·3	− 8·7	− 5·5	− 5·3	+5·8	+0·5
7	5	26	+ 2·6	−0·3	− 11·5	− 9·2	− 5·3	+5·6	+0·3
8	4	57	+ 8·5	−0·3	− 14·9	− 6·7	− 3·8	+5·1	+1·3
9	5	55	+17·9	−0·3	− 18·4	− 0·8	− 5·1	+4·3	−0·8
10	5	27	+17·0	−0·3	− 19·9	− 3·2	− 5·5	+3·3	−2·2
11	7	30	+20·7	−0·3	− 19·8	+ 0·6	− 5·4	+2·3	−3·1
12	7	3	+19·7	−0·3	− 18·3	+ 1·1	− 1·8	+1·4	−0·4
13	7	58	+19·7	−0·3	− 16·7	+ 2·7	− 2·0	0·0	−2·0
14	9	13	+15·6	−0·3	− 16·0	− 0·7	− 0·8	−1·4	−2·2
15	10	5	+15·0	−0·3	− 16·4	− 1·7	+ 2·1	−3·1	−1·0
17	16	19	+20·1	−0·3	− 19·5	+ 0·3	+ 5·6	−6·4	−0·8
18	17	19	+23·8	−0·3	− 20·2	+ 3·3	+ 4·4	−6·6	−2·2
19	16	48	+15·8	−0·3	− 19·9	− 4·4	+ 6·1	−5·7	+0·4
20	17	16	+15·9	−0·3	− 19·1	− 3·5	+ 4·6	−3·9	+0·7
21	18	6	+11·6	−0·3	− 18·3	− 7·0	+ 3·5	−2·0	+1·5
27	4	30	+18·8	−0·3	− 22·8	− 4·3	− 2·9	+3·9	+1·0
28	4	23	+12·9	−0·3	− 18·7	− 6·1	− 5·4	+3·8	−1·6
30	6	6	+ 1·7	−0·3	− 8·6	− 7·2	− 1·0	+3·5	+2·5
Dec. 1	6	5	− 3·8	−0·3	− 6·1	−10·2	− 5·5	+3·7	−1·8
2	4	31	− 1·8	−0·3	− 6·0	− 8·1	− 5·5	+4·1	−1·4
5	5	45	+ 8·7	−0·3	− 11·5	− 3·1	− 5·5	+4·1	−1·4
6	9	10	+ 5·3	−0·3	− 14·4	− 9·4	− 4·6	+3·8	−0·8
7	4	25	+13·1	−0·3	− 16·7	− 3·9	− 4·9	+3·5	−1·4
8	3	44	+11·9	−0·3	− 19·2	− 7·6	− 6·1	+2·7	−3·4
9	4	40	+15·8	−0·3	− 21·2	− 5·7	− 5·1	+1·8	−3·3
10	6	21	+22·0	−0·3	− 22·5	− 0·8	− 0·8	+1·0	+0·2
11	14	11	+25·4	−0·3	− 22·2	+ 2·9	− 0·6	−0·6	−1·2
12	19	3	+20·5	−0·3	− 20·2	0·0	+ 5·8	−2·6	+3·2
13	9	25	+16·0	−0·3	− 19·2	− 3·5	+ 4·3	−3·6	+0·7
14	11	2	+18·6	−0·3	− 18·8	− 0·5	+ 3·9	−5·6	−1·7
15	12	24	+16·1	−0·3	− 19·8	− 4·0	+ 8·0	−6·6	+1·4
16	14	50	+17·3	−0·3	− 22·1	− 5·1	+10·0	−6·4	+3·6
17	18	9	+21·8	−0·3	− 23·3	− 1·8	+ 5·7	−5·1	+0·6
18	16	29	+15·3	−0·3	− 22·0	− 7·0	+ 4·5	−3·1	+1·4
19	18	2	+14·9	−0·3	− 18·0	− 3·4	− 3·2	−0·6	−3·8
20	19	10	+13·2	−0·3	− 13·6	− 0·7	− 2·0	+1·5	−0·5
28	5	7	+ 3·3	−0·3	− 9·7	− 6·7	− 3·6	+1·6	−2·0
29	4	41	+ 1·5	−0·3	− 6·8	− 5·6	+ 0·2	+0·9	+1·1
30	4	18	− 0·7	−0·3	− 5·5	− 6·5	− 2·5	+0·3	−2·2

Errors of Hansen's Tables deduced

Approx. G.M.T. 1860.			Longitude.				N.P.D.		
	d h m	B-O	Corr. to B.	H-B	H-O		B-O	H-B	H-O
Jan. 1	7 58	− 1·0	−0·3	− 8·6	− 9·9		−2·5	+0·2	−2·3
2	4 8	+ 7·8	−0·3	− 11·1	− 3·6		−3·1	+0·3	−2·8
3	5 14	+ 5·0	−0·3	− 14·6	− 9·9		−4·5	+0·2	−4·3
4	4 5	+ 10·4	−0·3	− 17·3	− 7·2		−5·5	+0·3	−5·2
5	4 41	+ 11·4	−0·3	− 19·9	− 8·8		−4·2	+0·1	−4·1
6	5 25	+ 16·8	−0·3	− 22·5	− 6·0		−2·0	−0·2	−2·2
7	4 38	+ 13·1	−0·3	− 24·9	− 12·1		−1·0	−0·6	−1·6
8	7 55	+ 21·8	−0·3	− 26·8	− 5·3		−0·7	−1·5	−2·2
9	9 31	+ 21·1	−0·3	− 26·9	− 6·1		+2·4	−2·4	0·0
12	11 10	+ 19·5	−0·3	− 20·9	− 1·7		+6·9	−3·2	+3·7
15	15 22	+ 18·1	−0·3	− 21·0	− 3·2		−1·3	+1·3	0·0
16	17 57	+ 14·4	−0·3	− 17·2	− 3·1		−2·3	+3·6	+1·3
17	18 10	+ 2·4	−0·3	− 11·9	− 9·8		−8·8	+5·4	−3·4
25	5 41	+ 2·6	−0·3	− 8·1	− 5·8		−2·1	+1·8	−0·3
27	7 2	− 0·5	−0·3	− 6·5	− 7·3		−0·8	−0·2	−1·0
29	6 45	+ 0·5	−0·3	− 6·3	− 6·1		+2·3	−1·1	+1·2
31	5 2	+ 4·7	−0·3	− 11·0	− 6·6		−0·9	−1·2	−2·1
Feb. 1	10 8	+ 10·4	−0·3	− 15·8	− 5·7		+0·5	−1·1	−0·6
2	4 45	+ 11·6	−0·3	− 19·3	− 8·0		+0·4	−1·2	−0·8
3	5 42	+ 14·2	−0 3	− 23·3	− 9·4		+0·2	−1·5	−1·3
5	5 54	+ 25·5	−0·3	− 27·9	− 2·7		+2·2	−2·5	−0·3
6	6 1	+ 28·1	−0·3	− 29·2	− 1·4		+1·1	−2·9	−1·8
7	8 3	+ 25·2	−0·3	− 28·9	− 4·0		+4·3	−3·3	+1·0
9	10 15	+ 18·7	−0·3	− 23·2	− 4·8		+2·7	−1·5	+1·2
10	11 33	+ 16·9	−0·3	− 19·5	− 2·9		+2·0	0·0	+2·0
11	13 27	+ 10·3	−0·3	− 16·4	− 6·4		−2·2	+1·7	−0·5
12	15 55	+ 11·4	−0·3	− 14·5	− 3·4		−3·8	+3·9	+0·1
13	16 39	+ 11·0	−0·3	− 12·7	− 2·0		−7·8	+5·6	−2·2
14	18 0	+ 7·0	−0·3	− 9·8	− 3·1		−5·1	+7·2	+2·1
23	6 22	− 2·0	−0·3	− 2·4	− 4·7		−2·9	+1·9	−1·0
24	6 19	− 0·7	−0·3	− 4·9	− 5·9		+3·5	+1·2	+4·7
25	5 47	+ 0·4	−0·3	− 6·1	− 6·0		−0·2	+0·5	+0·3
27	5 27	− 1·0	−0·3	− 6·4	− 7·7		−1·4	+0·5	−0·9
28	6 16	+ 3·1	−0·3	− 8·1	− 5·3		−3·5	+0·9	−2·6
29	7 48	+ 9·9	−0·3	− 11·8	− 2·2		−1·2	+1·2	0·0
Mar. 1	5 9	+ 8·4	−0·3	− 16·0	− 7·9		−3·4	+0·7	−2·7
2	5 24	+ 15·5	−0·3	− 21·0	− 5·8		−3·3	−0·2	−3·5
3	6 5	+ 18·8	−0·3	− 24·4	− 5·9		−1·1	−1·4	−2·5
4	6 19	+ 22·9	−0·3	− 25·7	− 3·1		+4·6	−2·5	+2·1

Approx. G.M.T. 1860.			Longitude.				N.P.D.		
			B—O	Corr. to B.	H—B	H—O	B—O	H—B	H—O
	d	h m	"	"	"	"		"	"
Mar. 5		6 50	+21·3	−0·3	−25·8	− 4·8	+ 1·2	−3·6	−2·4
7		11 27	+18·3	−0·3	−24·1	− 6·1	+ 6·4	−3·4	+3·0
8		11 7	+18·8	−0·3	−22·5	− 4·0	+ 5·8	−2·5	+3·3
9		10 32	+16·2	−0·3	−19·3	− 3·4	− 0·9	−1·4	−2·3
11		15 44	+ 8·9	−0·3	−10·6	− 2·0	+ 1·3	+1·8	+3·1
14		17 14	+ 3·2	−0·3	− 7·6	− 4·7	− 6·8	+5·9	−0·9
15		18 23	+ 3·4	−0·3	− 5·0	− 1·9	− 4·8	+6·7	+1·9
24		8 9	− 3·6	−0·3	− 2·1	− 6·0	− 5·2	+0·7	−4·5
25		8 41	− 1·5	−0·3	− 5·9	− 7·7	− 5·7	+1·0	−4·7
26		6 46	+ 2·1	−0·3	− 8·5	− 6·7	+ 0·8	+1·1	+1·9
27		6 37	+ 3·7	−0·3	−11·1	− 7·7	− 2·7	+1·3	−1·4
28		7 37	+ 9·7	−0·3	−14·2	− 4·8	+ 0·2	+1·5	+1·7
29		6 52	+12·6	−0·3	−17·9	− 5·6	− 1·8	+1·1	−0·7
Apr. 1		6 47	+20·5	−0·3	−24·9	− 4·7	+ 2·3	−3·4	−1·1
2		5 26	+19·6	−0·3	−23·6	− 4·3	+ 1·6	−4·6	−3·0
3		7 11	+17·3	−0·3	−21·3	− 4·3	+ 6·4	−5·2	+1·2
4		7 12	+14·8	−0·3	−19·2	− 4·7	+ 4·3	−5·1	−0·8
5		9 49	+10·0	−0·3	−17·5	− 7·8	+ 6·4	−4·6	+1·8
6		9 17	+13·0	−0·3	−16·0	− 3·3	− 0·8	−3·7	−4·5
7		11 7	+ 6·9	−0·3	−14·1	− 7·5	+ 0·6	−2·6	−2·0
8		12 57	+ 8·0	−0·3	−12·0	− 4·3	+ 0·3	−1·2	−0·9
9		14 49	+11·0	−0·3	−10·7	0·0	− 1·0	+0·2	−0·8
10		15 6	+ 7·8	−0·3	−10·1	− 2·6	− 4·7	+1·5	−3·2
13		16 11	+ 6·0	−0·3	− 6·9	− 1·2	−10·1	+5·4	−4·7
25		7 38	+11·4	−0·3	−16·0	− 4·9	+ 0·8	+0·2	+1·0
26		8 0	+16·2	−0·3	−19·7	− 3·8	+ 2·7	−0·6	+2·1
27		7 54	+23·7	−0·3	−22·5	+ 0·9	+ 3·6	−1·9	+1·7
28		8 5	+22·3	−0·3	−24·5	− 2·5	+ 4·2	−3·2	+1·0
29		7 40	+21·9	−0·3	−25·2	− 3·6	+ 5·9	−4·5	+1·4
30		7 15	+22·2	−0·3	−24·2	− 2·3	+ 4·9	−5·3	−0·4
May 1		6 22	+16·3	−0·3	−22·1	− 6·1	+ 5·8	−5·4	+0·4
2		7 18	+17·2	−0·3	−19·2	− 2·3	+ 6·3	−4·8	+1·5
3		7 50	+12·6	−0·3	−17·2	− 4·9	+ 5·8	−4·0	+1·8
4		8 1	+ 7·1	−0·3	−16·3	− 9·5	+ 0·7	−3·2	−2·5
6		10 58	+ 6·1	−0·3	−13·8	− 8·0	+ 0·5	−1·6	−1·1
9		14 53	+ 5·0	−0·3	−12·4	·· 7·7	− 5·2	+1·7	−3·5
11		16 22	+ 1·9	−0·3	− 9·2	− 7·6	− 2·3	+4·1	+1·8
13		15 33	− 4·4	−0·3	− 5·3	−10·0	− 7·6	+5·0	−2·6
15		15 48	− 0·5	−0·3	+ 1·5	+ 0·7	− 0·7	+4·1	+3·4
22		8 45	+22·2	−0·3	−19·2	+ 2·7	+ 0·1	+2·0	+2·1
23		8 7	+21·6	−0·3	−22·8	− 1·5	+ 2·2	+1·1	+3·3
24		8 0	+22·0	−0·3	−24·2	− 2·5	+ 3·3	−0·3	+3·0

Approx. G.M.T. 1860.			Longitude.			R.N.P.D.		
	B−O	Corr. to B.	H−B	H−O	B−O	H−B	H−O
d h m							
May 26 8 49	+23·0	−0·3	−23·2	−0·5	+4·5	−2·7	+1·8
28 8 59	+19·0	−0·3	−20·9	−2·2	+4·5	−3·4	+1·1
29 7 23	+18·1	−0·3	−20·2	−2·4	+0·8	−2·6	−1·8
30 8 10	+16·5	−0·3	−19·8	−3·6	−0·9	−1·5	−2·4
31 12 57	+14·2	−0·3	−18·0	−4·1	+1·5	−0·3	+1·2
June 1 8 40	+13·9	−0·3	−16·6	−3·0	−0·3	+0·4	+0·1
3 10 55	+ 9·2	−0·3	−14·7	−5·8	−3·8	+1·5	−2·3
4 12 23	+ 8·5	−0·3	−14·9	−6·7	−1·4	+1·6	+0·2
5 11 47	+ 7·9	−0·3	−14·6	−7·0	−5·1	+1·1	−4·0
6 12 4	+ 8·4	−0·3	−13·4	−5·3	−2·8	+1·2	−1·6
10 12 41	+ 2·4	−0·3	− 6·4	−4·3	−4·6	+1·8	−2·8
12 15 34	+ 1·6	−0·3	− 5·1	−3·8	−3·6	+2·5	−1·1
13 14 43	+ 1·4	−0·3	− 3·9	−2·8	−4·9	+2·7	−2·2
14 13 41	− 0·6	−0·3	− 3·6	−4·5	−4·2	+3·3	−0·9
24 8 48	+20·2	−0·3	−24·8	−4·9	+2·2	−0·7	+1·5
26 7 11	+15·6	−0·3	−17·7	−2·4	−2·0	+0·8	−1·2
28 10 1	+13·3	−0·3	−15·7	−2·7	−2·8	+3·0	+0·2
29 11 39	+ 9·7	−0·3	−15·2	−5·8	+0·6	+4·2	+4·8
30 8 31	+11·6	−0·3	−14·9	−3·6	−6·3	+4·5	−1·8
July 1 9 28	+12·6	−0·3	−14·8	−2·5	−6·1	+4·4	−1·7
3 11 22	+ 8·6	−0·3	−13·8	−5·5	−3·9	+3·1	−0·8
4 11 10	+ 5·8	−0·3	−12·5	−7·0	−2·3	+2·1	−0·2
5 10 59	+ 1·7	−0·3	− 9·9	−8·5	−3·6	+0·9	−2·7
6 11 11	− 0·4	−0·3	− 6·6	−7·3	−5·9	−0·2	−6·1
7 11 24	+ 3·2	−0·3	− 4·3	−1·4	−4·8	−1·2	−6·0
11 12 41	+ 6·2	−0·3	− 8·0	−2·1	−3·6	−1·1	−4·7
12 14 35	+ 6·7	−0·3	− 8·9	−2·5	−0·4	−0·2	−0·6
18 2 55	+33·8	−0·3	−33·5	0·0	−2·0	+1·4	−0·6
22 8 54	+34·4	−0·3	−35·6	−1·5	0·0	−0·1	−0·1
23 8 40	+26·0	−0·3	−28·1	−2·4	+3·0	+0·3	+3·3
24 8 14	+17·3	−0·3	−21·4	−4·4	+1·5	+0·8	+2·3
25 8 11	+17·1	−0·3	−16·6	+0·2	−0·8	+1·7	+0·9
29 8 49	+ 5·3	−0·3	−10·9	−5·9	−4·7	+4·3	−0·4
30 8 19	+ 9·4	−0·3	−11·2	−2·1	−9·1	+4·2	−4·9
31 9 7	+ 7·5	−0·3	−11·5	−4·3	−5·9	+3·7	−2·2
Aug. 3 10 38	+ 3·2	−0·3	− 9·1	−6·2	+4·1	−0·9	+3·2
4 9 17	+ 0·6	−0·3	− 6·8	−6·5	−2·2	−1·9	−4·1
6 12 45	− 1·5	−0·3	− 3·6	−5·4	+1·9	−3·3	−1·4
7 11 3	+ 0·8	−0·3	− 4·8	−4·3	+2·3	−3·4	−1·1
9 14 22	+ 6·1	−0·3	−10·3	−4·5	−5·4	−2·3	−7·7
27 7 19	+ 0·6	−0·3	− 7·7	−7·4	−2·4	+2·4	0·0

Approx. G.M.T 1860			B–O	Longitude Corr. to B.	H–B	H–O	E.N.P.D. B–O	H–B	H–O
	d	h	m							
Aug. 29	9	18	+ 5·4	−0·3	− 8·9	−3·8	−0·6	+1·7	+1·1
30	8	28	+ 8·7	−0·3	−10·8	−2·4	−1·6	+0·7	−0·9
31	8	0	+ 6·2	−0·3	−12·2	−6·3	−2·7	−0·5	−3·2
Sept. 1	8	6	+ 7·6	−0·3	−12·4	−5·1	−3·5	−1·8	−5·3
2	9	21	+ 6·0	−0·3	−11·3	−5·6	+1·7	−2·9	−1·2
3	12	3	+ 2·0	−0·3	− 9·3	−7·6	+3·9	−3·5	+0·4
4	8	49	+ 4·1	−0·3	− 7·9	−4·1	+1·3	−3·2	−1·9
5	14	0	+ 3·9	−0·3	− 8·0	−4·4	+2·7	−2·7	0·0
6	9	26	+ 5·8	−0·3	− 9·8	−4·3	−1·5	−2·3	−3·8
7	11	37	+11·6	−0·3	−13·6	−2·3	+2·3	−2·1	+0·2
9	12	49	+13·5	−0·3	−18·4	−5·2	+0·8	−2·2	−1·4
10	12	58	+11·0	−0·3	−17·5	−6·8	−2·0	−2·7	−4·7
11	14	24	+14·4	−0·3	−16·6	−2·5	−6·7	−2·7	−9·4
12	16	24	+ 8·9	−0·3	−18·5	−9·9	+2·5	−3·2	−0·7
21	7	35	+17·0	−0·3	−19·3	−2·6	+0·8	+1·2	+2·0
25	6	46	+ 5·5	−0·3	− 8·3	−3·1	−3·4	+2·2	−1·2
26	6	5	+ 7·0	−0·3	− 8·6	−1·9	−0·2	+1·4	+1·2
29	15	33	+ 7·2	−0·3	−15·5	−8·6	+1·9	−2·1	−0·2
Oct. 1	10	24	+ 9·7	−0·3	−16·7	−7·3	+3·9	−3·5	+0·4
2	8	18	+12·5	−0·3	−15·8	−3·6	−0·3	−3·2	−3·5
3	7	56	+ 8·7	−0·3	−14·4	−6·0	−0·2	−2·9	−3·1
4	8	31	+11·6	−0·3	−13·3	−2·0	+0·2	−2·0	−1·8
5	8	45	+13·7	−0·3	−13·9	−0·5	+2·5	−1·9	+0·6
7	17	59	+15·8	−0·3	−19·6	−4·1	+1·3	−2·4	−1·1
9	14	10	+18·9	−0·3	−20·8	−2·2	−4·4	−3·0	−7·4
11	17	10	+13·4	−0·3	−20·2	−7·1	−2·6	−1·9	−4·5
20	5	59	+14·5	−0·3	−17·8	−3·6	−5·6	+4·4	−1·2
21	8	55	+ 5·1	−0·3	−12·7	−7·9	−5·0	+4·4	−0·6
22	5	59	+ 5·2	−0·3	−11·0	−6·1	−4·9	+4·2	−0·7
23	6	57	+ 4·7	−0·3	−10·6	−6·2	−4·5	+3·9	−0·6
24	7	28	+ 5·0	−0·3	−11·2	−6·5	−1·6	+2·7	+1·1
26	5	3	+11·2	−0·3	−13·1	−2·2	−2·4	+0·4	−2·0
27	5	51	+ 9·7	−0·3	−14·6	−5·2	−1·5	−0·6	−2·1
28	5	41	+12·8	−0·3	−16·4	−3·9	+1·1	−1·6	−0·5
29	5	50	+11·7	−0·3	−18·2	−6·8	0·0	−2·0	−2·0
30	5	25	+12·7	−0·3	−19·5	−7·1	−0·1	−2·4	−2·5
31	8	33	+15·8	−0·3	−19·6	−4·1	−1·3	−2·2	−3·5
Nov. 1	10	5	+11·2	−0·3	−17·9	−7·0	−0·2	−1·5	−1·7
2	7	34	+11·6	−0·3	−16·0	−4·7	−0·8	−1·2	−2·0
3	8	54	+10·3	−0·3	−14·9	−4·9	+0·6	−1·3	−0·7
4	10	2	+16·0	−0·3	−15·8	−0·1	−2·0	−2·0	−4·0

Errors of Hansen's Tables deduced

Approx. G.M.T. 1860			Longitude.				R.N.P.D.		
			B—O	Corr. to B.	H—B	H—O	B—O	H—B	H—O
	d	h	m							
Nov.	7	16	14	+19˝6	−0˝3	−22˝9	− 3˝6	−0˝4	−2˝1	−2˝5
	15	4	46	+26·0	−0·3	−28·6	− 2·9	−9·0	+7·1	−1·9
	16	4	54	+15·9	−0·3	−24·1	− 8·5	−6·8	+6·9	+0·1
	18	4	20	+ 5·5	−0·3	−13·8	− 8·6	−3·5	+5·4	+1·9
	19	4	42	+ 5·0	−0·3	−10·4	− 5·7	−4·9	+4·5	−0·4
	20	7	17	+ 2·8	−0·3	− 9·3	− 6·8	−2·2	+3·4	+1·2
	22	4	51	+ 1·1	−0·3	−11·4	−10·6	−2·5	+1·0	−1·5
	24	9	50	+ 5·3	−0·3	−13·6	− 8·6	+0·2	−1·5	−1·3
	27	6	4	+15·2	−0·3	−18·1	− 3·2	+0·6	−1·8	−1·2
	30	10	27	+14·8	−0·3	−18·6	− 4·1	+1·0	−1·1	−0·1
Dec.	4	13	26	+18·7	−0·3	−19·7	− 1·3	+4·7	−2·5	+2·2
	5	17	24	+19·2	−0·3	−22·7	− 3·8	+5·0	−1·8	+3·2
	6	16	23	+21·2	−0·3	−22·9	− 2·0	+2·4	−0·3	+2·1
	7	17	56	+15·3	−0·3	−20·2	− 5·2	+1·1	+1·9	+3·0
	16	4	39	+ 1·3	−0·3	−12·3	−11·3	−6·2	+4·6	−1·6
	18	5	55	+ 0·7	−0·3	− 7·3	− 6·9	+2·0	+1·2	+3·2
	19	5	7	+ 2·9	−0·3	− 7·1	− 4·5	+0·1	−0·3	−0·2
	20	5	29	0·0	−0·3	− 8·3	− 8·6	−1·9	−1·6	−3·5
	21	8	3	− 1·8	−0·3	−10·0	−12·8	+4·1	−2·5	+1·6
	22	6	7	+ 4·6	−0·3	−11·1	− 6·8	−0·6	−3·2	−3·8
	23	4	1	+ 7·0	−0·3	−12·1	− 5·4	+0·2	−3·5	−3·3
	24	4	57	+ 6·2	−0·3	−13·3	− 7·4	−1·7	−3·5	−5·2
	26	3	50	+14·1	−0·3	−17·6	− 3·8	−5·1	−2·9	−8·0
	28	6	32	+16·1	−0·3	−20·5	− 4·7	−0·8	−1·8	−2·6

Approx. G.M.T. 1861.			Longitude.				E.N.P.D.		
			B−O	Corr. to B.	H−B	H−O	B−O	H−B	H−O
Jan.	d h m		"	"	"	"	"	"	"
	1 16 38		+20·4	−0·3	−20·1	0·0	+ 1·6	−0·6	+1·0
	2 12 23		+21·9	−0·3	−21·8	− 0·2	− 0·3	−0·2	−0·5
	3 13 57		+17·8	−0·3	−23·4	− 5·9	+ 1·2	+1·2	0·0
	5 17 6		+19·9	−0·3	−20·8	− 1·2	−10·2	+5·7	−4·5
	18 8 28		− 4·3	−0·3	− 7·7	−12·3	+ 1·0	−3·6	−2·6
	21 6 45		+ 3·5	−0·3	−13·8	−10·6	+ 2·6	−4·3	−1·7
	23 17 14		+13·6	−0·3	−18·0	− 4·7	+ 4·3	−3·4	+0·9
	24 11 16		+13·1	−0·3	−19·0	− 6·2	+ 3·1	−3·2	−0·1
	25 18 17		+18·1	−0·3	−20·7	− 2·9	+ 4·3	−2·1	+2·2
	26 9 46		+17·5	−0·3	−21·4	− 4·2	+ 1·8	−1·7	+0·1
	27 7 55		+22·8	−0·3	−22·4	+ 0·1	+ 1·2	−0·9	+0·3
	28 9 6		+19·3	−0·3	−23·1	− 4·1	− 1·8	+0·4	−1·4
	29 9 51		+17·4	−0·3	−22·6	− 5·5	− 3·5	+1·5	−2·0
	30 20 1		+22·9	−0·3	−21·1	+ 1·5	− 4·1	+3·1	−1·0
Feb.	1 15 26		+17·4	−0·3	−20·4	− 3·3	− 6·2	+5·7	−0·5
	2 17 17		+12·3	−0·3	−20·0	+ 8·0	− 6·9	+7·5	+0·6
	11 5 51		− 1·4	−0·3	− 0·5	− 2·2	+ 2·2	+2·3	+4·5
	15 6 0		− 1·6	−0·3	− 4·8	− 6·7	+ 4·6	−2·4	+2·2
	16 9 16		− 1·9	−0·3	− 7·6	− 9·8	+ 4·3	−2·8	+1·5
	17 6 18		+ 3·0	−0·3	−10·4	− 7·7	+ 0·6	−3·0	−2·4
	18 5 26		+ 9·7	−0·3	−13·2	− 3·8	− 0·1	−3·1	−3·2
	19 5 14		+13·9	−0·3	−16·0	− 2·4	− 0·6	−3·3	−3·9
	21 9 8		+16·4	−0·3	−17·9	− 1·8	+ 3·7	−3·3	+0·4
	25 9 46		+16·0	−0·3	−21·2	− 5·5	− 2·0	+1·0	−1·0
	26 10 51		+19·2	−0·3	−21·2	− 2·3	− 5·5	+2·3	−3·2
	28 12 22		+20·0	−0·3	−15·6	+ 4·1	−11·7	+5·0	−6·7
Mar.	1 15 19		+11·2	−0·3	−13·3	− 2·4	− 8·5	+6·3	− 2·2
	3 17 17		+11·1	−0·3	−11·7	− 0·9	−11·4	+8·7	−2·7
	6 18 34		− 0·8	−0·3	+ 2·3	+ 1·2	− 5·3	+8·9	+3·6
	13 6 42		− 5·8	−0·3	+ 0·5	− 5·6	+ 4·6	−1·0	+3·6
	14 6 48		− 5·6	−0·3	− 2·1	− 8·0	+ 6·4	−1·7	+4·7
	15 6 5		− 4·0	−0·3	− 4·4	− 8·7	+ 2·7	−1·8	+0·9
	16 6 47		− 1·9	−0·3	− 7·0	− 9·2	+ 4·2	−1·8	+2·4
	17 7 37		+ 1·9	−0·3	−10·1	− 8·5	+ 2·3	−1·7	+0·6
	18 6 57		+ 2·7	−0·3	−12·8	−10·4	+ 4·1	−1·9	+2·2
	19 6 37		+ 9·5	−0·3	−15·6	− 6·4	+ 2·6	−2·3	+0·3
	20 10 40		+18·1	−0·3	−18·0	− 0·2	+ 5·2	−3·0	+2·2
	21 5 34		+11·3	−0·3	−18·5	− 7·5	+ 1·6	−3·5	−1·9
	22 6 28		+13·2	−0·3	−18·4	− 5·5	+ 2·5	−3·9	−1·4

Errors of Hansen's Tables deduced

Approx. G.M.T. 1861			B−O	Longitude. Corr. to B.	H−B	H−O	H.N.P.D. B−O	H−B	H−O
d	h	m							
Mar. 23	7	31	+12·4	−0·3	−17·5	−5·4	+5·0	−3·7	+1·3
26	11	39	+17·2	−0·3	−17·8	−0·9	−2·4	+0·4	−2·0
28	11	6	+8·4	−0·3	−15·3	−7·2	−8·0	+3·0	−5·0
29	12	57	+10·7	−0·3	−12·1	−1·7	−5·9	+3·9	−2·0
Apr. 4	17	29	−3·8	−0·3	+4·2	+0·1	−6·3	+6·0	−0·3
12	7	10	+1·0	−0·3	−5·2	−4·5	+6·6	−2·1	+4·5
16	7	7	+12·7	−0·3	−16·6	−4·2	+5·0	−2·5	+2·5
18	8	20	+12·1	−0·3	−19·4	−7·6	+0·7	−4·1	−3·4
19	11	13	+11·2	−0·3	−20·3	−9·4	+2·5	−4·6	−2·1
20	6	49	+15·3	−0·3	−20·3	−5·3	+5·7	−4·6	+1·1
21	7	36	+13·5	−0·3	−19·3	−6·1	+9·0	−4·3	+4·7
23	8	24	+13·6	−0·3	−17·8	−4·5	+2·3	−1·4	+0·9
24	8	47	+9·4	−0·3	−18·2	−9·1	−4·4	−0·2	−4·6
25	11	46	+10·7	−0·3	−19·1	−8·7	−2·8	+0·9	−1·9
27	13	51	+18·3	−0·3	−15·9	+2·1	−5·6	+2·6	−3·0
29	15	25	+2·8	−0·3	−8·5	−6·0	−7·5	+3·9	−3·6
May 1	15	46	+5·5	−0·3	−4·7	+0·5	−7·5	+4·2	−3·3
3	15	39	+4·6	−0·3	−1·2	+3·1	−6·6	+2·1	−4·5
4	15	57	−7·2	−0·3	+1·8	−5·7	−5·4	+0·6	−4·8
13	8	28	+15·7	−0·3	−17·9	−2·5	+5·2	−1·2	+4·0
14	9	11	+16·6	−0·3	−18·7	−2·4	+7·6	−1·6	+6·0
15	7	38	+18·1	−0·3	−18·9	−1·1	+5·4	−1·8	+3·6
16	9	41	+16·8	−0·3	−19·6	−3·1	+5·7	−2·4	+3·3
17	7	13	+16·3	−0·3	−20·7	−4·7	+4·0	−2·6	+1·4
18	8	32	+17·8	−0·3	−21·6	−4·1	+3·2	−2·3	+0·9
19	8	35	+19·6	−0·3	−21·4	−2·1	+3·7	−1·7	+2·0
20	8	12	+11·9	−0·3	−19·5	−7·9	+3·2	−0·5	+2·7
21	8	13	+16·0	−0·3	−17·8	−2·1	−3·9	+0·8	−3·1
22	9	49	+12·5	−0·3	−17·9	−5·7	−0·9	+2·0	+1·1
23	13	15	+16·7	−0·3	−19·4	−3·0	−6·2	+3·0	−3·2
24	11	2	+15·4	−0·3	−20·4	−5·3	−3·0	+3·4	+0·4
25	11	34	+21·7	−0·3	−19·9	+1·5	−6·8	+3·3	−3·5
26	12	15	+18·5	−0·3	−17·7	+0·5	−6·7	+3·0	−3·7
30	15	10	+7·6	−0·3	−8·4	−1·1	−0·8	0·0	−0·8
June 10	8	41	+15·2	−0·3	−20·3	−5·4	+2·1	+0·4	+2·5
12	8	17	+19·1	−0·3	−22·3	−3·5	+3·4	+0·7	+4·1
13	8	40	+23·9	−0·3	−22·1	+1·5	+2·6	+0·6	+3·2
14	8	51	+20·4	−0·3	−21·8	−1·7	−0·1	+0·9	+0·8
15	9	8	+16·8	−0·3	−21·4	−4·9	+0·5	+1·4	+1·9
16	9	38	+14·0	−0·3	−20·0	−6·3	+0·8	+2·4	+3·2
17	8	6	+18·1	−0·3	−18·4	−0·6	−3·0	+3·5	+0·5

Approx. G.M.T. 1861.			B−O	Longitude. Corr. to B.	H−B	H−O	E.N.P.D. B−O	H−B	H−O
	d	h m							
June 18	9	55	+ 12·6	−0·3	− 16·8	− 4·5	− 1·5	+4·9	+3·4
19	8	16	+ 8·2	−0·3	− 16·4	− 8·5	− 5·3	+6·0	+0·7
20	8	34	+ 7·1	−0·3	− 16·7	− 9·9	− 7·0	+6·8	−0·2
22	10	14	+ 11·9	−0·3	− 16·5	− 4·9	− 8·8	+6·9	−1·9
23	10	43	+ 11·3	−0·3	− 15·6	− 4·6	− 9·6	+5·9	−3·7
24	11	19	+ 8·0	−0·3	− 14·0	− 6·3	− 9·2	+4·5	−4·7
25	11	2	+ 10·2	−0·3	− 12·5	− 2·6	− 7·2	+2·9	−4·3
26	12	14	+ 5·2	−0·3	− 10·7	− 5·8	− 4·9	+0·8	−4·1
27	11	40	+ 9·2	−0·3	− 9·4	− 0·5	− 4·8	−1·1	−5·9
30	14	28	+ 3·7	−0·3	− 7·5	− 4·1	− 0·5	−4·8	−5·3
July 3	13	38	+ 1·1	−0·3	− 5·4	− 4·6	− 0·9	−3·7	−4·6
4	14	27	+ 2·9	−0·3	− 6·2	− 3·6	− 3·3	−2·7	−6·0
11	8	42	+ 28·8	−0·3	− 28·5	0·0	− 2·1	+1·7	−0·4
14	8	59	+ 19·1	−0·3	− 20·7	− 1·9	− 1·9	+3·0	+1·1
15	8	44	+ 16·4	−0·3	− 17·9	− 1·8	− 3·7	+3·7	0·0
16	9	19	+ 19·0	−0·3	− 15·8	+ 2·9	− 6·0	+4·8	−1·2
17	10	46	+ 11·8	−0·3	− 15·4	− 3·9	− 6·6	+6·0	−0·6
18	9	32	+ 18·4	−0·3	− 16·1	+ 2·0	− 9·7	+7·1	−2·6
20	10	53	+ 12·1	−0·3	− 15·4	− 3·6	− 12·2	+8·0	−4·2
21	10	11	+ 9·2	−0·3	− 14·8	− 5·9	− 6·7	+7·2	+0·5
23	9	55	+ 10·0	−0·3	− 13·6	− 3·9	− 8·1	+4·0	−4·1
26	11	22	+ 2·3	−0·3	− 7·1	− 5·1	− 1·1	−1·9	−3·0
27	11	7	+ 6·5	−0·3	− 5·6	− 0·6	− 0·1	−3·2	−3·3
28	11	45	− 0·8	−0·3	− 5·0	− 6·1	+ 0·3	−3·9	−3·6
29	11	53	− 3·1	−0·3	− 5·6	− 9·0	+ 0·2	−4·2	−4·0
30	11	33	+ 4·9	−0·3	− 6·6	− 2·0	− 0·3	−4·3	−4·6
Aug. 1	13	9	− 0·5	−0·3	− 7·9	− 8·7	− 0·6	−3·4	−4·0
12	7	13	+ 14·0	−0·3	− 20·4	− 6·7	− 2·3	+1·1	−1·2
14	8	22	+ 12·5	−0·3	− 15·3	− 3·1	− 4·1	+2·2	−1·9
15	6	47	+ 9·9	−0·3	− 15·1	− 5·5	− 4·8	+3·3	−1·5
16	10	8	+ 11·9	−0·3	− 15·2	− 3·6	− 8·0	+4·5	−3·5
17	10	30	+ 11·3	−0·3	− 15·6	− 4·6	− 7·5	+5·0	−2·5
18	7	40	+ 17·9	−0·3	− 16·3	+ 1·3	− 4·5	+4·8	+0·3
19	8	1	+ 14·6	−0·3	− 17·7	− 3·4	− 6·9	+4·0	−2·9
20	8	28	+ 14·0	−0·3	− 18·7	− 5·0	− 2·8	+2·8	0·0
21	8	21	+ 11·6	−0·3	− 18·3	− 7·0	− 7·4	+1·2	−6·2
23	9	14	+ 13·4	−0·3	− 11·7	+ 1·4	− 3·5	−1·8	−5·3
24	9	9	+ 1·2	−0·3	− 7·1	− 6·2	+ 0·2	−2·7	−2·5
25	10	56	+ 0·1	−0·3	− 4·0	− 4·2	− 0·2	−2·9	−3·1
26	9	37	− 2·2	−0·3	− 3·6	− 6·1	− 0·9	−2·8	−3·7
27	10	18	+ 2·3	−0·3	− 5·0	− 3·0	− 0·9	−3·0	−3·9
28	10	38	+ 1·6	−0·3	− 7·5	− 6·2	+ 2·1	−3·4	−1·3

Approx. G.M.T. 1861.			Longitude.				N.P.D.		
			B−O	Corr. to B.	H−B	H−O	B−O	H−B	H−O
	d h m								
Aug. 30	13	8	+ 10″·1	−0″·3	− 11″·5	− 1″·7	+ 1″·0	− 4″·2	− 3″·2
31	15	10	+ 7·6	−0·3	− 13·4	− 6·1	+ 4·4	− 4·4	0·0
Sept. 1	16	4	+ 11·0	−0·3	− 16·9	− 6·2	+ 2·2	− 4·3	− 2·1
10	6	45	+ 18·9	−0·3	− 22·2	− 3·6	− 1·9	+ 1·9	0·0
11	7	14	+ 9·7	−0·3	− 17·0	− 7·6	− 2·9	+ 2·4	− 0·5
12	7	20	+ 10·5	−0·3	− 13·8	− 3·6	− 4·5	+ 2·7	− 1·8
13	6	52	+ 13·0	−0·3	− 12·4	+ 0·3	− 5·0	+ 3·3	− 1·7
14	6	41	+ 11·1	−0·3	− 12·2	− 1·4	− 5·1	+ 3·2	− 1·9
15	11	31	+ 6·5	−0·3	− 13·3	− 7·1	− 2·0	+ 2·7	+ 0·7
16	8	58	+ 11·7	−0·3	− 15·6	− 4·2	− 1·1	+ 1·8	+ 0·7
17	10	25	+ 14·9	−0·3	− 18·2	− 3·6	− 1·0	+ 0·5	− 0·5
18	6	41	+ 20·8	−0·3	− 20·0	+ 0·5	− 6·3	− 0·6	− 6·9
19	7	18	+ 17·9	−0·3	− 21·0	− 3·4	− 1·6	− 1·9	− 3·5
20	7	17	+ 18·9	−0·3	− 19·3	− 0·7	− 2·2	− 2·9	− 5·1
21	10	10	+ 9·7	−0·3	− 14·8	− 5·4	+ 1·0	− 3·5	− 2·5
23	8	9	+ 1·6	−0·3	− 7·1	− 5·8	− 2·8	− 3·1	− 5·9
24	10	4	+ 5·6	−0·3	− 5·7	− 0·4	+ 0·6	− 3·1	− 2·5
25	13	6	+ 0·5	−0·3	− 7·4	− 7·2	+ 1·6	− 3·3	− 1·7
26	11	0	+ 10·1	−0·3	− 10·5	− 0·7	− 3·8	− 4·1	− 7·9
27	12	0	+ 14·5	−0·3	− 14·0	+ 0·2	− 3·1	− 4·9	− 8·0
28	16	58	+ 13·4	−0·3	− 17·8	− 4·7	+ 4·4	− 5·6	− 1·2
Oct. 8	6	0	+ 27·6	−0·3	− 32·2	− 4·9	− 10·5	+ 6·1	− 4·4
9	6	4	+ 15·2	−0·3	− 24·1	− 9·2	− 8·2	+ 6·5	− 1·7
10	8	57	+ 17·2	−0·3	− 17·3	− 0·4	− 3·5	+ 6·6	+ 3·1
11	8	15	+ 8·7	−0·3	− 13·8	− 5·4	− 4·8	+ 6·2	+ 1·4
12	6	37	+ 9·3	−0·3	− 12·1	− 3·1	− 2·5	+ 5·2	+ 2·7
13	5	38	+ 8·3	−0·3	− 11·5	− 3·5	− 5·9	+ 4·0	− 1·9
14	5	0	+ 8·8	−0·3	− 11·6	− 3·1	− 5·2	+ 2·4	− 2·8
15	5	34	+ 9·2	−0·3	− 12·6	− 3·7	− 3·6	+ 0·5	− 3·1
16	8	39	+ 9·5	−0·3	− 14·4	− 5·2	− 0·8	− 1·2	− 2·0
17	5	30	+ 9·4	−0·3	− 16·2	− 7·1	− 1·1	− 2·3	− 3·4
18	6	36	+ 13·0	−0·3	− 18·0	− 5·3	+ 1·7	− 3·4	− 1·7
19	5	53	+ 14·1	−0·3	− 18·7	− 4·9	− 1·9	− 3·8	− 5·7
20	8	29	+ 12·4	−0·3	− 17·4	− 5·3	− 1·0	− 3·9	− 4·9
21	8	49	+ 13·8	−0·3	− 14·8	− 1·3	− 3·1	− 3·4	− 6·6
22	8	29	+ 5·5	−0·3	− 11·8	− 6·6	+ 0·4	− 3·0	− 2·6
23	8	0	+ 1·6	−0·3	− 10·0	− 8·7	+ 1·1	− 2·6	− 1·5
24	9	46	+ 6·1	−0·3	− 10·1	− 4·3	+ 4·8	− 2·7	+ 2·1
25	14	38	+ 9·7	−0·3	− 13·4	− 4·0	+ 3·8	− 3·5	+ 0·3
26	11	48	+ 12·6	−0·3	− 17·2	− 4·9	− 1·3	− 4·0	− 5·3
27	18	9	+ 16·6	−0·3	− 22·4	− 6·1	+ 3·1	− 3·9	− 0·8
28	14	52	+ 22·3	−0·3	− 24·6	− 2·6	− 0·6	− 3·3	− 3·0

Approx. G.M.T. 1861			Longitude.				E N.P.D.		
			B−O	Corr. to B.	H−B	H−O	B−O	H−B	H−O
d	h	m							
Oct. 29	18	49	+21ʺ8	−0ʺ3	−25ʺ3	− 3ʺ8	− 0ʺ1	−1ʺ6	−1ʺ7
Nov. 5	5	26	+32·3	−0·3	−34·6	− 2·6	−11·0	+9·1	−1·9
6	6	6	+24·9	−0·3	−28·2	− 3·6	− 8·3	+9·1	+0·8
7	5	19	+14·8	−0·3	−22·4	− 7·9	− 8·3	+8·6	+0·3
8	4	42	+13·4	−0·3	−17·9	− 4·8	− 6·1	+7·7	+1·6
9	4	38	+ 9·5	−0·3	−15·4	− 6·2	− 6·7	+6·1	−0·6
10	7	42	+ 8·3	−0·3	−14·0	− 6·0	− 5·5	+3·9	−1·6
11	4	30	+ 6·7	−0·3	−13·3	− 6·9	− 1·9	+1·9	0·0
12	8	43	+ 7·9	−0·3	−12·5	− 4·9	+ 2·2	−0·6	+1·6
15	5	49	+ 4·9	−0·3	−12·1	− 7·5	− 1·5	−3·7	−5·2
16	4	51	+10·4	−0·3	−13·4	− 3·3	− 1·4	−3·8	−5·2
17	6	17	+ 9·9	−0·3	−15·5	− 5·9	− 4·6	−3·5	−8·1
18	7	13	+13·8	−0·3	−16·6	− 3·1	+ 0·2	−2·9	−2·7
19	6	49	+13·4	−0·3	−16·3	− 3·2	− 1·8	−2·2	−4·0
20	8	19	+11·5	−0·3	−14·7	− 3·5	+ 2·1	−1·5	+0·6
21	13	46	+ 9·3	−0·3	−12·1	− 3·1	− 0·4	−0·6	−1·0
22	11	58	+ 5·1	−0·3	−11·4	− 6·6	− 1·3	−0·6	−1·9
23	16	24	+13·6	−0·3	−13·1	+ 0·2	+ 0·7	−0·7	0·0
24	12	55	+11·5	−0·3	−15·9	− 4·7	− 0·7	−0·6	−1·3
26	18	55	+24·4	−0·3	−20·5	+ 3·6	− 3·3	+1·3	−2·0
Dec. 4	4	37	+24·0	−0·3	−22·9	+ 0·8	− 4·3	+9·1	+4·8
5	4	48	+16·3	−0·3	−19·8	− 3·8	− 5·0	+8·0	+3·0
7	9	7	+ 3·6	−0·3	−13·9	−10·6	− 3·6	+3·7	+0·1
8	3	55	+ 7·5	−0·3	−13·2	− 6·0	− 1·3	+2·0	+0·7
9	3	32	+ 7·1	−0·3	−13·1	− 6·3	− 0·8	−0·3	−1·1
11	4	27	+11·3	−0·3	−13·6	− 2·6	+ 1·6	−4·2	−2·6
12	10	8	+ 8·3	−0·3	−12·8	− 4·8	+ 6·5	−5·4	+1·1
13	7	27	+ 6·7	−0·3	−11·7	− 5·3	+ 5·0	−5·7	−0·7
14	8	36	+ 1·4	−0·3	−11·0	− 9·9	+ 2·4	−5·5	−3·1
15	8	28	+ 4·2	−0·3	−11·2	− 7·3	+ 2·1	−4·6	−2·5
17	7	34	+13·6	−0·3	−13·7	− 0·4	+ 0·2	−2·9	−2·7
18	7	35	+11·9	−0·3	−14·6	− 3·0	+ 1·8	−1·9	−0·1
19	7	17	+ 4·1	−0·3	−14·5	−10·7	+ 0·9	−0·8	+0·1
20	11	36	+ 7·2	−0·3	−12·4	− 5·5	− 0·7	+0·1	−0·6
23	17	53	+14·6	−0·3	−13·3	+ 1·0	− 5·5	+1·5	−4·0
24	13	49	+10·8	−0·3	−14·8	− 4·3	− 1·9	+2·2	+0·3
25	15	44	+10·3	−0·3	−14·9	− 4·9	− 7·0	+3·3	−3·7
26	19	15	+ 8·7	−0·3	−12·0	− 3·6	− 3·5	+5·0	+1·5

₊ In accordance with a resolution of the Council passed at their meeting on June 13, the advertisement of the papers to be read at the evening meetings will be no longer inserted in the *Times* newspaper.   In lieu thereof, post-cards containing the titles of papers will be sent to such Fellows of the Society as shall express their wish to receive them.   Fellows desiring to receive the post-cards are requested to send their names to the Assistant-Secretary.

In order to enable the Secretaries to prepare complete lists in time for the issue of the post-cards, authors are particularly requested to send in their papers not later than the Tuesday preceding the day of meeting.

The present number of the *Monthly Notices* being the last of Vol. L., Subscribers (not Fellows) are requested to take notice that the Subscription for Vol. LI., 10s., including postage to countries within the Postal Union, has now become due; and it is also requested that it may be forwarded to the Assistant-Secretary, Mr. W. H. WESLEY, Burlington House, London, W., on or before December 1 next; otherwise it will be considered that the Subscription has not been renewed.